paralysis in poliomyelitis; this is done in all patients who require reconstructive measures and have active power in both inner and outer hamstring groups. This practice has completely eliminated the complication of postoperative lateral dislocation of the patella, yet has maintained the desirable features of the hamstring transplantation.

In four cases of the present series with completely paralyzed biceps and quadriceps, the semitendinosus alone was transplanted forward to the patella. In these cases, the transplantation was done chiefly to relieve a persistently recurring flexion deformity of the knee, yet in two instances excellent function has resulted.

In this Clinic, a total of 134 hamstring transplantations for the relief of residua quadriceps paralysis in poliomyelitis have been observed, including the original sixty-three cases reported by Crego and Fischer. The follow-up periods range from one to twenty-tw years.

An analysis of the end results in the present study will be presented; and the pri ciples, technique, and conclusions set forth in the original report will be modified, a indicated.

RESULTS

The results of the present analysis of cases are reported according to the followi grouping:

1. *Transplantation of the Biceps Femoris Alone to the Patella:* A total of 100 su transplantations were performed; eleven of these patients subsequently had the s tendinosus transplanted to the patella to correct lateral dislocation of the patella.

2. *Transplantation of the Biceps Femoris and Semitendinosus to the Patella:* In ninetee of a total of thirty such cases, the biceps and semitendinosus were transplanted simultaneously as the initial operative procedure. In the remaining eleven cases the biceps femoris had originally been transplanted; the semitendinosus was transplanted secondarily, in addition to the tibial tubercle, to relieve lateral dislocation of the patella.

3. *Transplantation of the Semitendinosus Alone to the Patella:* In four cases, transplanta tion of the semitendinosus alone was done primarily to relieve recurrent flexion deformi of the knee, due to muscle imbalance around the knee. In these cases the biceps femori as well as the quadriceps, was paralyzed.

Results are considered *excellent* in those cases with:

1. Normal active power of extension;
2. No recurvatum;
3. Brace-free extremity;
4. No lateral displacement of patella;
5. Stability of knee in walking.

Good results comprise those cases with:

1. Active extension, 135 to 180 degrees;
2. Recurvatum absent to mild;
3. Brace-free extremity;
4. No lateral displacement of patella;
5. Stability of knee in walking.

With *fair* results, there is:

1. Active extension, 95 to 135 degrees;
2. Recurvatum absent to moderate;
3. Brace-free extremity;
4. No lateral displacement of patella;
5. Stability of knee in walking.

Poor results are characterized by:

1. Total failure of transplant to extend knee;
2. Severe, painful, or disabling recurvatum;

Bone and Joint Surgery

American Volume

HAMSTRING-TENDON TRANSPLANTATION FOR THE RELIEF OF QUADRICEPS FEMORIS PARALYSIS IN RESIDUAL POLIOMYELITIS

A FOLLOW-UP STUDY OF 134 CASES *

BY J. R. SCHWARTZMANN, M.D., AND C. H. CREGO, JR., M.D., ST. LOUIS, MISSOURI

From the Shriners' Hospital for Crippled Children, St. Louis

In 1931, Crego and Fischer reported the end results in sixty-three cases in which the ceps femoris tendon had been transplanted to the patella for relief of residual quadriceps ıralysis in poliomyelitis. In that report, sixty of sixty-one cases were regarded as being tisfactory, and about 62 per cent. of these were classed as having excellent results. The iginal report covered follow-up periods of from one to six years.

Many of the original sixty-three cases have now been followed for as long as fifteen twenty-two years; and certain factors, resulting in failure of the transplant to produce satisfactory end result, have appeared as the follow-up period lengthened.

The report of the first sixty-three cases in this series embraced the transplantation of e biceps femoris alone to the patella, to restore extensor power in the knee. As the follow-) period in these and subsequent cases lengthened, it became apparent that lateral dis- cation of the patella following operation was being observed more and more frequently, d that additional surgical procedures were required to correct the patellar displacement. his complication alone became a contra-indication to the operative procedure. With the ıtella completely displaced laterally, due to unbalanced pull of the biceps femoris, there a loss of extension by this transplanted biceps, as a result of change in mechanical pull ɔss the knee-joint hinge. Although in many instances it has been observed that, with ɩe knee in full extension, the position can be maintained even with a laterally displaced ıtella, active extension from flexion cannot be accomplished, and thus the practical value the transplant is lost. At the present time, twenty-nine of 100 biceps femoris trans- ɹntations are known to have resulted in lateral dislocation of the patella; there may well ɜ more than this number.

Surgical correction of the lateral dislocation eventually resolved itself into a shifting the tibial tubercle medially on the tibial shaft, combined with transferance of the ːmitendinosus forward, to restore balance in the pull on the patella by the transplants. ransplantation of the tibial tubercle alone did not prove uniformly successful in pre- enting redislocation of the patella.

In 1927, one case of quadriceps paralysis was treated, as the initial reconstructive ocedure, by the simultaneous transplantation of the biceps and semitendinosus forward the patella. This case was graded as excellent after a follow-up period of eight years.

Since 1935, it has been the general rule in this Clinic to transplant simultaneously oth the biceps and semitendinosus forward to the patella for relief of residual quadriceps

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, nuary 28, 1948.

Hamstring power, of course, is necessary for eventual extension after transplantation; however, in two instances in which the inner hamstrings were graded as poor or less, the semitendinosus was nevertheless transplanted to the patella. This was done because we believed that the transplanted inner hamstring, although weak, would act as a check-sling on the patella, to prevent lateral dislocation.

In the earlier report, normal power in the gastrocnemius was a requisite for the selection of cases suitable for operation, since it was believed that weakness of this muscle would result in recurvatum and thus negate the value of the hamstring transplantation. A normal calf group is not essential for excellent results, but it is desirable, since many patients who were examined depended entirely upon contraction of the gastrocnemius for obtaining active flexion of the knee postoperatively. From 10 to 15 degrees of active flexion against gravity, from complete extension, was the maximum observed from contraction of the gastrocnemius alone. Strong gastrocnemius power, it is believed, helps to control the tendency to recurvatum after operation. Weak calf power, however, is not the major factor in producing recurvatum, since of twenty-three patients in whom recurvatum developed, only six had less than fair power in the calf group, whereas seven had fair power, four had good power, and six had normal power.

In general, then, we believe that, from a standpoint of muscle power, *those patients are eligible for reconstructive surgery who have sufficient residual muscle power to warrant the reasonable expectation that apparatus can be discarded postoperatively.*

As stated in the original report, active cooperation on the part of the patient is essential for postoperative rehabilitation, since careful and diligent postoperative physiotherapy is required to realize early maximum benefit from the operative procedure. Mental inability to cooperate is a contra-indication to reconstructive surgery.

Fixed deformities, such as flexion of the hip, flexion of the knee, and equinus of the foot, must be corrected before hamstring transplantation. Correction of flexion deformities of the hip and knee *after* hamstring transplantation shortens the distance from origin to insertion of the muscles and thus weakens the power of contraction. Uncorrected equinus of the foot causes compensatory recurvatum.

OPERATIVE TECHNIQUE

The operative technique remains the same as that originally described by Crego and Fischer for transplantation of the biceps femoris alone. In transplanting the biceps and

TABLE II

PREOPERATIVE POWER OF PERTINENT MUSCLE GROUPS AS COMPARED WITH FINAL GRADING OF TRANSPLANT

Final Result from Transplantation	Power of Various Muscle Groups—Poor or Less in:					
	Glutaeus Maximus (*Per cent.*)	Hip Flexors (*Per cent.*)	Outer Hamstrings (*Per cent.*)	Inner Hamstrings (*Per cent.*)	Calf Muscles (*Per cent.*)	Quadric[eps] (*Per cent.*)
Excellent (Biceps transplant)	6	35	6	9	12	97
Poor (Biceps transplant)	19	48	8	16	22	92
Excellent (Biceps and semitendinosus transplants)	5	25	0	10	5	85
Poor (Biceps and semitendinosus transplants)	0	0	0	0	25	100

TABLE IV

PATIENTS WITH POOR OR LESS POWER IN CALF GROUP

Operative Procedure	Per cent.
Biceps transplantation alone	
Resulting in recurvatum	25
Graded as excellent	12
Biceps and semitendinosus transplantation	
Resulting in recurvatum	29
Graded as excellent	5

angular pathway to the patella decreases the efficiency of the muscle pull. This principle is brought out in detail in the technique of biceps transplantation. The semitendinosus tendon is then anchored into the body of the patella, with that of the biceps. Figure 1 demonstrates the appearance of the completed transplantation.

It is important to stress the necessity for care in dissecting the biceps and semitendinosus tendons from their insertions, since it is essential to preserve the tibial and fibular collateral ligaments intact, and either or both could be divided during the dissection.

Five cases of biceps transplantation alone, one case of biceps and semitendinosus transplantation, and one case of semitendinosus transplantation alone were classified as poor, because of lateral instability of the knee, for which protective braces were required after operation. This instability may have been due to operative division of the collateral ligaments.

POSTOPERATIVE CARE

Upon completion of the operation, the extremity is immobilized in plaster-of-Paris from groin to toes, with the knee in from 175 to 180 degrees of extension. Forced hyperextension is unnecessary, and aids in the development of postoperative recurvatum by stretching the posterior supportive structures of the knee joint.

It was formerly stressed that postoperative flexion of the hip must be avoided. The present survey has shown that, on numerous occasions, the patient has been found sitting upright in bed on the first postoperative day and subsequently. In no instance has this resulted in failure or in impaired end results.

Physiotherapy is begun between the third and fourth week after operation, as originally described; complete removal of plaster during the eighth week is followed by active flexion of the knee against gravity. As soon as sufficient power has been obtained to stabilize the knee in extension, the patient becomes ambulatory without braces. In the last five semitendinosus and biceps transplantations in this study (where the cases have been followed from one to four years), no postoperative apparatus has been used, and the

TABLE V

RELATIONSHIP OF MUSCLE POWER IN PATIENTS WITH RECURVATUM

Operative Procedure	Poor or Less in: Glutaeus Maximus (*Per cent.*)	Hip Flexors (*Per cent.*)	Outer Hamstrings (*Per cent.*)	Inner Hamstrings (*Per cent.*)	Calf Muscles (*Per cent.*)	Quadriceps (*Per cent.*)
Transplantation of biceps alone	13	56	6	19	25	100
Transplantation of biceps and semitendinosus	0	14	0	0	29	100

3. Brace required after surgery;
4. Lateral displacement of patella;
5. Instability of knee in walking.

Excellent, *good*, and *fair* results are considered satisfactory. *Poor* results are considered satisfactory.

Table I shows that transplantation of the semitendinosus and the biceps to the patella relief of quadriceps paralysis produced 30 per cent. more excellent results than trans- antation of the biceps femoris alone. Biceps *and* semitendinosus transfers resulted in per cent. of satisfactory results, as compared with 56 per cent. of satisfactory results om the transplantation of the biceps alone.

Transplanting the semitendinosus alone to the patella resulted in three satisfactory ..lts in four cases, since this operation was done primarily to relieve the cause of recur- nt flexion deformity of the knee with paralyzed quadriceps and paralyzed outer ham- rings, rather than to obtain active power in extension of the knee.

SELECTION OF CASES AND REQUIREMENTS FOR SURGERY

In the original report of this series, the importance of adequate power in various uscle groups around the hip and knee, as a prerequisite to selection of a case for recon- uctive surgery, was stressed. At that time it was felt that fair or better power in the ip flexors, glutaeus maximus, hamstrings, and the gastrocnemius and soleus groups 's essential to good end results. Certainly a maximum amount of power in these muscle ups is desirable, but it is not an essential requisite for the selection of cases. In Table II shown the relative strengths of these various muscle groups, excellent and poor results eing compared in the two major groupings.

Hip extensor and hip flexor power is important for ease in walking up and down stairs.

TABLE I

RESULTS OF HAMSTRING TRANSPLANTATIONS FOR QUADRICEPS PARALYSIS

ollow-up (*Years*)	Excellent	Good	Fair	Poor	Total
		Transplantation of Biceps Femoris Alone			
to 22	13	5	4	13	35
to 7	11	6	3	24	44
to 3	11	1	2	2	16
nknown					5
Totals	35 (35%)	12 (12%)	9 (9%)	39* (39%)	100
		Transplantation of Biceps Femoris and Semitendinosus			
to 9	17	2	3	4	26
to 3	3	0	1	0	4
Totals	20 (67%)	2 (7%)	4 (13%)	4 (13%)	30**
		Transplantation of Semitendinosus Alone			
o 11	2 (50%)	1 (25%)	0	1 (25%)	4

* In twenty-nine biceps transplantations with poor results, the patients had lateral subluxation of the tella; eleven of these had secondary semitendinosus transplantations, three had other operations for cor- tion of the dislocation.

** Eleven of these were secondary transplantations of the semitendinosus, to correct subluxation of the tella after biceps transplantation alone. Nine finally were rated as excellent; two finally were rated as poor.

Recurvatum, then, results from the combination of factors just mentioned, and the authors believe that the development of recurvatum will be kept to a minimum if the following conditions exist:

1. Fair or better power is present in the gastrocnemius;
2. Postoperative hyperextension of the knee in plaster is avoided;
3. Equinus deformity is corrected before weight-bearing is begun postoperatively;
4. Postoperative braces which will throw the knee into recurvatum are avoided;
5. Diligent postoperative physiotherapy, to promote active flexion of the knee, is carried out.

Total failure of the transplant to function occurred in six cases (Table VI). Four of these were biceps transplantations alone, one was a biceps and semitendinosus transplantation, and one was a transplantation of the semitendinosus alone. In only one case with total failure of the transplantation was this factor the sole cause of unsatisfactory rating; this was in a case in which the biceps alone had been transplanted.

CONCLUSIONS

On the basis of a follow-up study of 134 hamstring transplantations, the following conclusions are given:

1. Hamstring substitution for residual quadriceps paralysis in poliomyelitis is a highly satisfactory operative procedure.
2. Simultaneous transplantation of the biceps femoris and semitendinosus to the patella is a much more satisfactory reconstructive procedure and produces far better results than transplantation of the biceps alone.
3. Certain principles governing selection of cases, operative technique, and postoperative care, as set forth in the original report of this series of cases, have been altered in accordance with the analysis of results.

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DISCUSSION

Dr. Theodore H. Vinke, Cincinnati, Ohio: I congratulate Dr. Schwartzmann and Dr. Crego for the excellent presentation of their subject, and the analysis of their cases. I agree entirely with their conclusions. My discussion will be limited to other details which concern the transplantation of the hamstrings to the patella. In 1934, I studied this problem in its relation to kinetics; I referred to the work of Dr. R. Scherb and Dr. Arthur Steindler.

It is noted that the hamstrings can flex the knee and can also extend it, if the extremity is fixed and the pelvis is free to move upward, causing the tibia to be pulled posteriorly. The fact that the hamstring has extensor action under certain conditions makes it suitable for transplantation to the patella in cases of quadriceps paralysis.

My studies by means of a myokinesimeter, in 1934, showed that the period of contraction of the hamstrings is long, and overlaps the period of contraction of the quadriceps. Both flexors and extensors can act together to a certain extent for the purpose of stabilization. The use of two hamstrings is shown statistically in Dr. Schwartzmann's and Dr. Crego's paper to be the method of choice. It is indeed rational that a pull from both sides of the patella is mechanically desirable. The method of fixing a tendon to the center of the patella, in order that the pull should be exerted in the vertical direction as much as possible, is important not only to prevent dislocation, but also to obtain the most effective action for the production of extension. Even if one muscle transplant is stronger than the other, one will act as a "guide wire" in preventing dislocation, and will also aid in producing muscle pull in the proper direction. This is particularly true in cases of valgus of the knee, when the patella tends to be displaced laterally. Transplanting two hamstrings is also important, in that as much power as possible is transferred anteriorly in order to make up for the paralysis of the quadriceps, particularly in view of the fact that the quadriceps muscles have three times as much strength as the combined power of the hamstrings.

Contraction of the quadriceps tightens not only the tendinous insertion, pulling the patella upward, but also puts tension on the entire anterior reinforcing apparatus of the knee, and thus aids considerably in the stabilization of this joint. The rectus femorus alone is not able to accomplish full extension under ordinary circumstances. When the knee is forcibly extended, the patella is drawn strongly upward by the quadriceps. In this extended position, the quadriceps muscles aid stabilization. The anterior capsule is too large and too loose to produce stability.

The lateral ligaments of the knee assist greatly in the stabilization of the joint, because the posterior part becomes taut when the knee is in complete extension. If the transplanted hamstrings can maintain extension of the knee during certain phases of gait, a satisfactory result is obtained, because stability is acquired and braces can be discarded.

The inner hamstrings rotate the tibia inward, and outward rotation is produced by the extensor fascia. Rotary motion necessarily follows extension and flexion of the knee.

The transplanted muscles can be made to perform a new function without too much difficulty. The problem of re-education is often not much more difficult than muscle training after other operative procedures about the knee. The hamstring muscles are long, because they must accommodate a large range of motion about the knee. For this reason, they are suitable for transplantation to the patella, for here, also, a long range of motion is required. The individual muscle fiber is able to contract only from one-fourth to one-half of its length in the relaxed position. This is sufficient to extend the knee, if the point of application of force is near the joint.

The importance of maximum power in various muscle groups about the hip and knee, as a prerequisite to selection of cases for hamstring transplantation, has been stressed. Although this is desirable, it is not essential.

It is also important that sufficient muscle power be present about the foot and ankle. In cases of muscle weakness in this region, reconstructive surgery of the foot makes it possible for the transplanted hamstrings to function more efficiently.

The most favorable results of forward transplantation of both hamstrings, in cases of weak or paralyzed quadriceps, are obtained if the hip and foot are sufficiently stable.

Dr. Frederick J. Fischer, Detroit, Michigan: The authors have again emphasized the criteria for selection of cases, the operative procedure, and the postoperative management which are so important and which must be adhered to, if a satisfactory result is to be obtained. The objective of the procedure is the elimination of a brace.

A series of twenty-eight cases of hamstring-tendon transfer, in which operations were performed at the Detroit Orthopaedic Clinic and the Children's Hospital of Michigan, were reviewed for study. The average age of these patients at the time of review was twenty years; the average follow-up period was nine years, the minimum follow-up period, three and one-half years.

Of the twenty-eight cases, twenty-three represented biceps transfers alone, three represented inner-hamstring transfers alone, and two were combined transfers of biceps and semitendinosus tendons. Of the biceps transfers, all but two could be considered satisfactory, as judged by the criteria established by the authors of this paper.

Recurvatum of some degree was present in seven or 25 per cent. of the cases. In one case this complication, plus lateral instability, made for an unsatisfactory result. The patient was quite obese, and this was thought to be a major cause in the production of the deformity. One patient had a slight recurvatum prior to surgery, which increased. Of the remaining five, three had good to normal muscle capacity in the gastrocnemius.

As regards lateral dislocation or subluxation of the patella, the results were less discouraging than in the authors' series. One patient demonstrated a slight subluxation in the initial 15 degrees of extension, and another patient in the final 15 degrees of extension. The former seemed to be due to an uncorrected valgus deformity of 7 degrees, and the latter to an undesirable obliquity of pull of the transplant. In neither case was this complication severe enough to warrant an additional inner-hamstring transfer for correction.

One of the poor results was due to complete failure of the transplant to contract.

All five patients with inner-hamstring transfers alone, or combined biceps and inner-hamstring transfers, eventually had satisfactory results.

In none of the cases could an appreciable recovery in the quadriceps femoris be detected, following hamstring-tendon transfer.

Although a review of our results in an admittedly small series of cases does not emphasize lateral dislocation of the patella as a frequent complication of biceps transfer alone, in light of the authors' experience with a much larger series of cases, we believe that the combined transfer should eliminate this hazard. We enthusiastically support hamstring-tendon transfer as an excellent surgical procedure.

Dr. J. R. Schwartzmann (closing): Three days ago I hesitated even to read this paper, since apparently no other clinic has encountered the problem of lateral displacement of the patella following this transplanta-

(*Continued on page 559*)

TABLE III

INCIDENCE OF COMPLICATIONS FOLLOWING TRANSPLANTATION

	Recurvatum	Lateral Dislocation of Patella	Lateral Instability of Knee	Complete Failure of Transplant
s transplant alone	16 (16%)	29 (29%)	5 (5%)	4 (4%)
s and semitendinosus transplants	7 (23%)	0	1 (3%)	1 (3%)
endinosus transplant alone	0	0	1	1

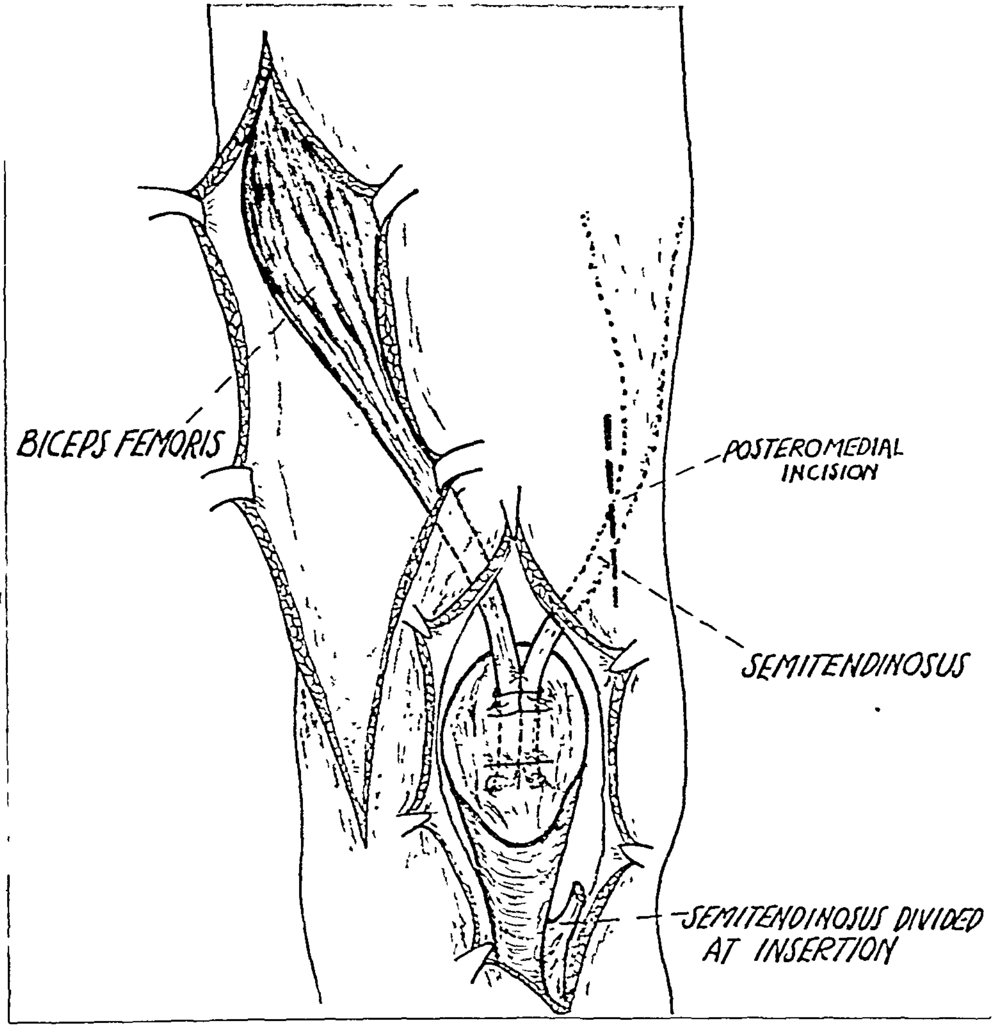

FIG 1

Transplantation of semitendinosus and biceps tendons to patella

semitendinosus simultaneously, the additional procedure of detaching the semitendinosus from its insertion in the upper portion of the tibia, and drawing the tendon out through an incision over the musculotendinous juncture of the semitendinosus on the posteromedial aspect of the thigh, is carried out. The fascia of the muscle is split longitudinally toward its origin, sufficiently to allow the tendon to be threaded forward, through an oblique subcutaneous tunnel, toward the patella Care must be taken that the tunnel is directed in a gradually oblique direction toward the patella, and that the fascia of the muscle is opened sufficiently to allow the muscle a gradual oblique pull on the patella, since a sharp

FRACTURES OF THE TALUS

BY MAJOR BARNARD KLEIGER

Medical Corps, Army of the United States

It is generally known that the end results of fractures of the talus have often been bad. In the past these fractures have been infrequent, and the reported series of Schrock, McKeever, Miller and Baker, Boyd and Knight, Lipscomb and Ghormley, Shands, Wilson, and others have not been large; only a few of their patients had fresh fractures, treated immediately after injury. The recent War increased exposure to trauma in industrial and military life and increased the frequency of all fractures, including those of the talus. Fortunately, the military medical organization permitted immediate clinical and roentgenographic examination and treatment of the injured. We are, therefore, able to present twenty-nine cases of fresh fracture of the talus, for which treatment was started soon after the injury. The end results of several old injuries are used for illustration.

The anatomy of the talus is too well known to warrant complete discussion at this time. Its position in the line of weight-bearing and its many articular surfaces indicate clearly that any deformity of the bone will cause serious disability in the ankle.

Osseous repair following fracture of the talus is made more precarious by the relative paucity of its blood supply. In this respect, it resembles the head of the femur and the carpal navicular. According to McKeever, the entire arterial supply is from a small articular branch of the dorsalis pedis artery, which enters the lateral aspect of the neck of the talus. This may be the largest and most important of the arteries, but our own observations agree with those of Sneed and Watson-Jones that smaller nutrient vessels help supply the talus through its many and widespread ligamentous attachments. In this series, aseptic necrosis appeared only when the fractured body was dislocated posterior to the tibia, thereby tearing most of its ligamentous attachments. As revascularization progressed, the normal bone density returned, extending posteriorly from the fracture line and anteriorly from the posterior tubercle of the talus (Fig. 1-A). This left a triangular wedge of dense bone in the center of the body. As the bone healed, this wedge gradually narrowed (Fig. 1-B). In an unusual case, the head and neck fragment was displaced and rotated from its normal position. The fragment was replaced and it healed, but subsequently a large zone of aseptic necrosis involved the fracture site, the distal portion of the neck and head, and, to a lesser extent, the body of the talus (Figs. 2-A and 2-B). This also indicated that circulation entered through both fragments. Furthermore, if blood were to enter the talus only through the neck, then the small fragment of the posterior tubercle would invariably become necrotic when fractured. This has not been true in the present series (Fig. 3).

Of the twenty-nine fresh fractures of the talus, eleven were simple linear fractures through the body, close to its juncture with the neck (Fig. 4). Most of these were incurred by soldiers, landing from parachute jumps, when the foot was sharply dorsiflexed by the force of landing on the fore part of the foot, with or without additional inversion. These fractures were treated by simple immobilization in a plaster boot. Weight-bearing was forbidden for four weeks. Then the plaster was removed and a roentgenogram was taken to determine whether or not aseptic necrosis had appeared. If it had not appeared, a skin-tight walking plaster was applied for another four weeks, by which time union was complete. The results in these cases were almost uniformly good. In no patient did aseptic necrosis develop, and there were few residual clinical symptoms. Many of these soldiers eventually returned to parachute jumping, and all who had uncomplicated fractures returned to duty. Two cases were complicated by additional fractures, and the results were not quite so good as in the others. One soldier had a fracture of the intertrochanteric region of the femur and a chip fracture of the distal end of the fibula, on the same ex-

TABLE VI

CAUSES OF FAILURE OF THE TRANSPLANTATION

Cause of Failure	Length of Follow-up (*Years*)	No. of Cases
mplete lateral displacement of patella, preventing active extension	22	1
ilure of patient to cooperate in postoperative physiotherapy	6	1
or power in transplanted muscles	22 5	2
o apparent reason	6 11	2

atients have had satisfactory results. In none of these patients has recurvatum developed, and it is now believed that postoperative braces may favor rather than prevent he development of recurvatum.

COMPLICATIONS AND CAUSES OF FAILURE

Factors causing failure of the operative procedures (Table III) were:

1. Lateral displacement of the patella;
2. Recurvatum, disabling in degree, requiring a brace after operation;
3. Total failure of the transplant to function:
4. Instability of the knee,—disabling and requiring a brace after operation.

Formerly, genu recurvatum was described as being the most frequent cause of failure of the operative procedure. After a longer period of observation, it has been found that lateral dislocation of the patella is a more common cause. This complication has not appeared in any of those cases in which both biceps and semitendinosus were transplanted. and it is for this reason that transplantation of the biceps femoris alone has been discontinued. In five cases, recurvatum was the *sole* cause of unsatisfactory results. Three of these were cases of biceps transplantation alone; two included the biceps and semitendinosus. In these cases, recurvatum was sufficiently severe to require that a protective brace be continued permanently.

An analysis of preoperative muscle power in those cases in which recurvatum developed (Table V), as compared with the muscle power in the cases having excellent results after biceps transplantation and after biceps and semitendinosus transplantation (Table II), indicates only one factor of significance. and that is in the preoperative power in the calf group. Those patients with recurvatum had poor or less power in the calf muscles in both operative groups in a significantly greater proportion than did the patients with excellent results in those groups (Table IV).

The common factor in all cases in which recurvatum developed is the removal of the major portion of the muscle mass which supports the knee joint posteriorly and which, by virtue of its action, aids in the prevention of the back-knee deformity. The very nature of the procedure requires that this factor be introduced; since only five cases, or about 4 per cent., were failures because of recurvatum alone. and since only twenty-three, or 17 per cent., of all cases had some degree of recurvatum. the authors do not consider this factor to be a contra-indication to the surgical procedure.

If the other factors contributing to recurvatum—namely, equinus deformity of the foot, postoperative hyperextension of the knee in plaster, and postoperative braces—are avoided, if care is taken to select those with adequate power in the gastrocnemius, and if postoperative physiotherapy is diligently practised, the removal of the supporting muscle mass from behind the knee at operation is less likely to produce the deformity.

Recurvatum, then, results from the combination of factors just mentioned, and the authors believe that the development of recurvatum will be kept to a minimum if the following conditions exist:

1. Fair or better power is present in the gastrocnemius;
2. Postoperative hyperextension of the knee in plaster is avoided;
3. Equinus deformity is corrected before weight-bearing is begun postoperatively;
4. Postoperative braces which will throw the knee into recurvatum are avoided;
5. Diligent postoperative physiotherapy, to promote active flexion of the knee, is carried out.

Total failure of the transplant to function occurred in six cases (Table VI). Four of these were biceps transplantations alone, one was a biceps and semitendinosus transplantation, and one was a transplantation of the semitendinosus alone. In only one case with total failure of the transplantation was this factor the sole cause of unsatisfactory rating; this was in a case in which the biceps alone had been transplanted.

CONCLUSIONS

On the basis of a follow-up study of 134 hamstring transplantations, the following conclusions are given:

1. Hamstring substitution for residual quadriceps paralysis in poliomyelitis is a highly satisfactory operative procedure.
2. Simultaneous transplantation of the biceps femoris and semitendinosus to the patella is a much more satisfactory reconstructive procedure and produces far better results than transplantation of the biceps alone.
3. Certain principles governing selection of cases, operative technique, and postoperative care, as set forth in the original report of this series of cases, have been altered in accordance with the analysis of results.

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DISCUSSION

Dr. Theodore H. Vinke, Cincinnati, Ohio: I congratulate Dr. Schwartzmann and Dr. Crego for the excellent presentation of their subject, and the analysis of their cases. I agree entirely with their conclusions. My discussion will be limited to other details which concern the transplantation of the hamstrings to the patella. In 1934, I studied this problem in its relation to kinetics; I referred to the work of Dr. R. Scherb and Dr. Arthur Steindler.

It is noted that the hamstrings can flex the knee and can also extend it, if the extremity is fixed and the pelvis is free to move upward, causing the tibia to be pulled posteriorly. The fact that the hamstring has extensor action under certain conditions makes it suitable for transplantation to the patella in cases of quadriceps paralysis.

My studies by means of a myokinesimeter, in 1934, showed that the period of contraction of the hamstrings is long, and overlaps the period of contraction of the quadriceps. Both flexors and extensors can act together to a certain extent for the purpose of stabilization. The use of two hamstrings is shown statistically in Dr. Schwartzmann's and Dr. Crego's paper to be the method of choice. It is indeed rational that a pull from both sides of the patella is mechanically desirable. The method of fixing a tendon to the center of the patella, in order that the pull should be exerted in the vertical direction as much as possible, is important not only to prevent dislocation, but also to obtain the most effective action for the production of extension. Even if one muscle transplant is stronger than the other, one will act as a "guide wire" in preventing dislocation, and will also aid in producing muscle pull in the proper direction. This is particularly true in cases of valgus of the knee, when the patella tends to be displaced laterally. Transplanting two hamstrings is also important, in that as much power as possible is transferred anteriorly in order to make up for the paralysis of the quadriceps, particularly in view of the fact that the quadriceps muscles have three times as much strength as the combined power of the hamstrings.

Contraction of the quadriceps tightens not only the tendinous insertion, pulling the patella upward, but also puts tension on the entire anterior reinforcing apparatus of the knee, and thus aids considerably in the stabilization of this joint. The rectus femoris alone is not able to accomplish full extension under ordinary circumstances. When the knee is forcibly extended, the patella is drawn strongly upward by the quadriceps. In this extended position, the quadriceps muscles aid stabilization. The anterior capsule is too large and too loose to produce stability.

The lateral ligaments of the knee assist greatly in the stabilization of the joint, because the posterior part becomes taut when the knee is in complete extension. If the transplanted hamstrings can maintain extension of the knee during certain phases of gait, a satisfactory result is obtained, because stability is acquired and braces can be discarded.

The inner hamstrings rotate the tibia inward, and outward rotation is produced by the extensor fascia. Rotary motion necessarily follows extension and flexion of the knee.

The transplanted muscles can be made to perform a new function without too much difficulty. The problem of re-education is often not much more difficult than muscle training after other operative procedures about the knee. The hamstring muscles are long, because they must accommodate a large range of motion about the knee. For this reason, they are suitable for transplantation to the patella, for here, also, a long range of motion is required. The individual muscle fiber is able to contract only from one-fourth to one-half of its length in the relaxed position. This is sufficient to extend the knee, if the point of application of force is near the joint.

The importance of maximum power in various muscle groups about the hip and knee, as a prerequisite to selection of cases for hamstring transplantation, has been stressed. Although this is desirable, it is not essential.

It is also important that sufficient muscle power be present about the foot and ankle. In cases of muscle weakness in this region, reconstructive surgery of the foot makes it possible for the transplanted hamstrings to function more efficiently.

The most favorable results of forward transplantation of both hamstrings, in cases of weak or paralyzed quadriceps, are obtained if the hip and foot are sufficiently stable.

Dr. Frederick J. Fischer, Detroit, Michigan: The authors have again emphasized the criteria for selection of cases, the operative procedure, and the postoperative management which are so important and which must be adhered to, if a satisfactory result is to be obtained. The objective of the procedure is the elimination of a brace.

A series of twenty-eight cases of hamstring-tendon transfer, in which operations were performed at the Detroit Orthopaedic Clinic and the Children's Hospital of Michigan, were reviewed for study. The average age of these patients at the time of review was twenty years: the average follow-up period was nine years, the minimum follow-up period, three and one-half years.

Of the twenty-eight cases, twenty-three represented biceps transfers alone, three represented inner-hamstring transfers alone, and two were combined transfers of biceps and semitendinosus tendons. Of the biceps transfers, all but two could be considered satisfactory, as judged by the criteria established by the authors of this paper.

Recurvatum of some degree was present in seven or 25 per cent. of the cases. In one case this complication, plus lateral instability, made for an unsatisfactory result. The patient was quite obese, and this was thought to be a major cause in the production of the deformity. One patient had a slight recurvatum prior to surgery, which increased. Of the remaining five, three had good to normal muscle capacity in the gastrocnemius.

As regards lateral dislocation or subluxation of the patella, the results were less discouraging than in the authors' series. One patient demonstrated a slight subluxation in the initial 15 degrees of extension, and another patient in the final 15 degrees of extension. The former seemed to be due to an uncorrected valgus deformity of 7 degrees, and the latter to an undesirable obliquity of pull of the transplant. In neither case was this complication severe enough to warrant an additional inner-hamstring transfer for correction.

One of the poor results was due to complete failure of the transplant to contract.

All five patients with inner-hamstring transfers alone, or combined biceps and inner-hamstring transfers, eventually had satisfactory results.

In none of the cases could an appreciable recovery in the quadriceps femoris be detected, following hamstring-tendon transfer.

Although a review of our results in an admittedly small series of cases does not emphasize lateral dislocation of the patella as a frequent complication of biceps transfer alone, in light of the authors' experience with a much larger series of cases, we believe that the combined transfer should eliminate this hazard. We enthusiastically support hamstring-tendon transfer as an excellent surgical procedure.

Dr. J. R. Schwartzmann (closing): Three days ago I hesitated even to read this paper, since apparently no other clinic has encountered the problem of lateral displacement of the patella following this transplanta-

(Continued on page 559)

RADICAL OPERATIVE TREATMENT OF THE TUBERCULOUS HIP

A Report of 113 Cases

BY ALBERT AHLBERG, M.D., VARBERG, SWEDEN

From the Kustsanatoriet Apelviken, Varberg

As far as can be ascertained, the first genuine resection of the hip joint was performed by an Englishman, Anthony White, in 1821. In 1874, a Danish practitioner, Ludvig Jacobsen, reviewed in a thesis 250 cases of hip-joint resection, many of which were for tuberculosis; 104 patients were cured, while 146 died. This comprised all the cases of hip-joint resection published up to that date. Dr. Jacobsen explained these poor results mainly by stating that the operations had been performed at too late a stage.

The author has been unable to obtain any detailed reports of similar operations, which undoubtedly must have been performed in the decades that followed. Since the 1920's, more conservative methods have been tried, such as extra-articular operations, which in some instances have been combined with intra-articular arthrodesis. There are three main reasons why intra-articular fusion in tuberculosis has lost favor: (1) the high mortality rates mentioned in earlier publications, (2) the risk of dissemination of the tuberculous process, and (3) the difficulty of establishing continuity for fusion between the head of the femur and the acetabulum. All cases of coxitis naturally cannot be treated by radical operation, but the indications could undoubtedly be made wider than they have previously been, without any detriment to the results.

TABLE I

Number of Patients Treated by Operation

Year	Males			Females			Total
	Resection	Extra-Articular Fixation	Resection plus Extra-Articular Fixation	Resection	Extra-Articular Fixation	Resection plus Extra-Articular Fixation	
1929				1			1
1930	1						1
1931			1	1			2
1932	4	1		5	3	1	14
1933	6	3	3		2	4	18
1934	2	2	1	4	2		11
1935	4			4		1	9
1936	6	1		3	3		13
1937	5	1		1			7
1938	3			3	2		8
1939	11	1		1	1		14
1940	1	1		4			6
1941	4			3			7
1942	7			2			9
1943	2			3	1		6
1944	7			4			11
Totals	63	10	5	39	14	6	137

TABLE II

AGE AT TIME OF OPERATION

Age Group (Years)	Males		Females		Total
	Resection	Resection plus Extra-Articular Fixation	Resection	Resection plus Extra-Articular Fixation	
7			1		1
10 to 15	3	1	2		6
16 to 20	7	1	10	2	20
21 to 25	24	1	8	1	34
26 to 30	10		5	2	17
31 to 35	9	1	2		12
36 to 40	5		4	1	10
41 to 45	2	1	4		7
46 to 50	2				2
51 to 55	1		2		3
56 to 60			1		1
Totals	63	5	39	6	113

GENERAL SURVEY OF MATERIAL

The end results are presented in 113 cases of the so-called radical operation, done at our Hospital during the years from 1929 through 1944. These 113 cases represent 82.5 per

TABLE III

NUMBER OF HOSPITAL ADMISSIONS BEFORE OPERATION

Year of Operation	Hospital Period										Total
	I		II		III		IV		V		
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	
1929		1									1
1930	1										1
1931		1			1						2
1932	1	2	2	4			1				10
1933	6	3	2		1			1			13
1934	2	2	1	2							7
1935	3	4	1	1							9
1936	5	2	1							1	9
1937	5	1									6
1938	3	3									6
1939	9	1	1		1						12
1940	1	4									5
1941	4	2		1							7
1942	6	1	1					1			9
1943	1	3	1								5
1944	3	3	2	1	2						11
Totals	50	33	12	9	5	0	1	2	0	1	113

M. = Males
F. = Females

TABLE IV

ASSOCIATED LESIONS INVOLVING OTHER PARTS OF THE BODY IN FORTY-THREE PATIENTS

Diagnosis	Males	Females	Total
Pulmonary tuberculosis	6	10	16
Tuberculous lymphoma		1	1
Renal tuberculosis	2	1	3
Tuberculous epididymitis	2		2
Tuberculous peritonitis	2	1	3
Tuberculous spondylitis	6	4	10
Tuberculous osteitis of the trochanter	8	1	9
Costal tuberculosis	1		1
Tuberculosis of the elbow		2	2
Tuberculosis of the shoulder	2		2
Tuberculosis of the knee	2		2
Tuberculosis of the sacro-iliac joint	1	3	4
Tarsal tuberculosis	1		1
Tuberculosis of the ischium	1		1
Totals	34	23	57

cent. of the total number of operations on the hip joint. The remaining 17.5 per cent of the patients operated upon represent extra-articular fusion alone or extra-articular fusion as a reinforcing operation for resection (Table I). The total of 137 patients operated

TABLE V

CLINICAL AND ROENTGENOGRAPHIC FINDINGS AT DISCHARGE

Group	Clinical Findings		Roentgenographic Findings		Total
	Ankylosis	No Ankylosis	Fusion of Joint	No Fusion	
I: Males	26	13	5	34	39
Females	16	10	1	25	26
II: Males	1	11		12	12
Females	1	5		6	6
III: Males		3		3	3
Females	3	2		5	5
IV: Males	2	3	2	3	5
Females	3	3		6	6
V: Males					
Females	1			1	1
Totals					
Males	29	30	7	52	59
Females	24	20	1	43	44
Grand total	53	50	8	95	103

Group I: Small defects in head and neck of femur and in acetabulum. Good contact between the resected surfaces is possible.
Group II: Large defects in head and neck and in acetabulum. Defective contact between the resected surfaces.
Group III: Cases where the tip of the trochanter was placed in the acetabulum to serve as a lateral support.
Group IV: Cases where resection and extra-articular fixation were done in one operation.
Group V: Cases where extra-articular fixation was done later (but before the first discharge from the Hospital).

FIG. 1-A FIG. 1-B FIG. 1-C

Fig. 1-A. Mar. 30, 1943. Roentgenogram of a girl, fourteen years of age.
Fig. 1-B: Six months later (Sept. 28, 1943).
Fig. 1-C Two years later (Mar. 16, 1945).

FIG. 2-A FIG. 2-B FIG. 2-C

Fig. 2-A: Roentgenogram, taken Aug. 8, 1933, of a boy, seventeen years old.
Fig. 2-B: Operation was performed on Oct. 26, 1934. Roentgenogram shows hip three months after operation (Feb. 6, 1934).
Fig 2-C: Nine years and eleven months after operation (Sept. 13, 1943).

FIG. 3-A FIG. 3-B FIG. 3-C

Fig. 3-A: Preoperative roentgenogram, taken Feb. 13, 1936, of a man, twenty-two years old. Operation was performed the next day.
Fig. 3-B: Two months after operation (Apr. 17, 1936).
Fig. 3-C: Seven years and seven months after operation (Sept. 6, 1943).

upon represent 15.6 per cent. of 879 cases of tuberculosis of the hip, treated from 1929 to 1944, inclusive. Table II shows the cases divided according to age at the time of operation.

The mean time in the Hospital before the operation was eleven months for males and thirteen months for females. Seventy-three per cent. of the patients operated upon had their operations during the first hospital period (Table III). Those who were operated upon during subsequent hospital admissions were those who had either not been cured during their first stay or had had recurrences. A few were subsequently operated upon for malposition of the hip. The disease had been present in some cases for as long as one year before the first admission to the Hospital. In seventy patients, the hip joint was the only seat of the tuberculous process.

FIG. 4-A FIG. 4-B FIG. 4-C

Fig. 4-A: Right hip of a man, twenty-eight years old. Roentgenogram taken Aug. 26, 1936, one week before operation.
Fig. 4-B: Two months after operation (Oct. 27, 1936).
Fig. 4-C: Roentgenogram taken Sept. 11, 1943, seven years after operation.

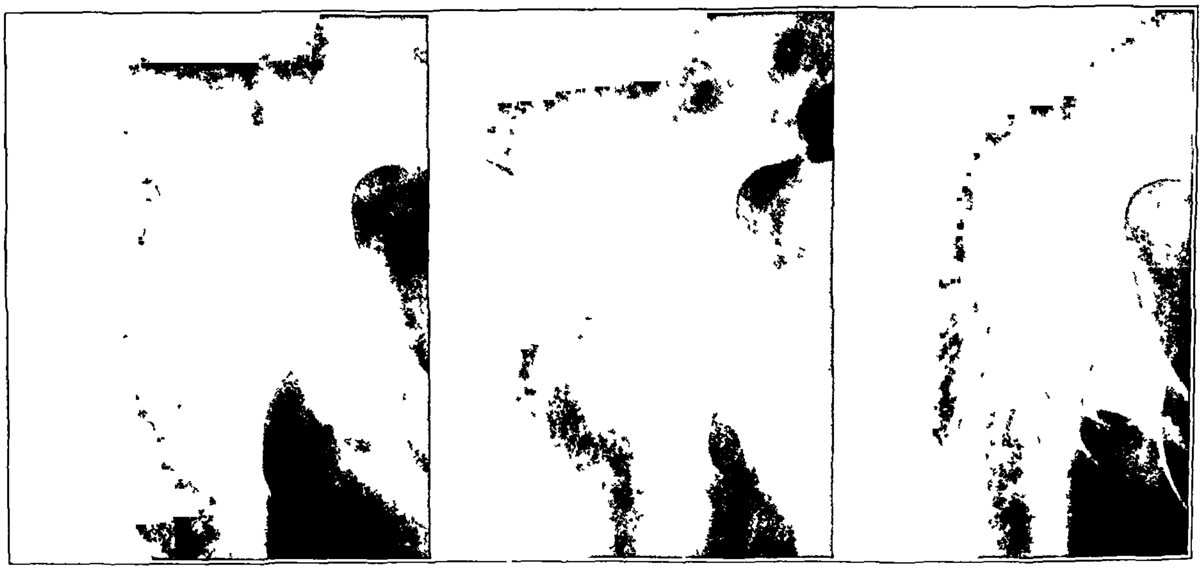

FIG. 5-A FIG. 5-B FIG. 5-C

Fig. 5-A: Preoperative roentgenogram of hip, taken June 30, 1939. The patient was a man, twenty-four years old.
Fig. 5-B: Shows appearance of hip on Sept. 12, 1939, one month after operation.
Fig. 5-C: Four years after operation (Sept. 8, 1943).

FIG. 6-A FIG. 6-B FIG. 6-C

Fig. 6-A: Roentgenogram, taken Oct. 28, 1942, shows hip of a man, twenty-two years old. Operation was performed nine days later.
Fig. 6-B: Four months after operation (Mar 15, 1943).
Fig. 6-C: Two years and ten months after operation (Aug 30, 1945).

Table IV shows the distribution of associated lesions in the remaining forty-three. In a number of cases, several parts were involved at once.

DIAGNOSIS

The diagnosis of tuberculosis of the hip may be regarded as established in all of these cases. In 81.4 per cent. of the cases, the diagnosis was verified by histological examination, guinea-pig inoculation, or culture evidence. The remaining twenty-one patients displayed, at operation, lesions in the form of small abscesses, patches of cheesy necrosis, or granulation tissue of typical tuberculous appearance. In half of the patients, a limp was reported. Twenty-eight had abscesses on admission and nineteen displayed fistulae. Roentgenographically, all but eight showed advanced decalcification. All showed a joint space which was narrowed, absent, or destroyed. In fifty-three cases, sequestra were visible; six had subluxations and four showed frank dislocation.

Diagnosis at an early stage is not always easy, and the characteristic that should be especially stressed is the insidious nature of the disease.

FIG. 7-A FIG. 7-B FIG. 7-C

Fig. 7-A: Roentgenogram, taken Mar. 14, 1944, shows hip of a man, twenty-four years of age.
Fig. 7-B: Operation was carried out on Apr. 5, 1944. Shows appearance of hip on July 11, 1944, three months later.
Fig 7-C: One year and two months after operation (June 18, 1945).

TABLE VI

ROENTGENOGRAPHIC FINDINGS IN NINETY-NINE PATIENTS*

Group	Patients Examined at Follow-up		Patients Who Replied to Questionnaire and Sent Roentgenograms		Patients not Followed (Findings at Discharge)	
	Fusion	No Fusion	Fusion	No Fusion	Fusion	No Fusion
I: Males	14	7	7	8	2	1
Females	11	6	3	2		1
II: Males	2	5	1	2		1
Females	1	2				
III: Males	2	1				
Females	4	1				
IV: Males	3			1		
Females	5	1				
V: Males						
Females		1	1			
VI: Males		1				
Females	2					
Totals						
Males	21	14	8	11	2	2
Females	23	11	4	2		1
Grand total	44	25	12	13	2	3

* Cases are divided into groups, as in Table V. Group VI has been added, and includes those patients operated upon at a later hospital period, an extra-articular fixation being then done. These cases have been included in other groups in previous tables.

OPERATION

The vast majority of these patients were operated upon by the technique described by Lecène, with modifications introduced by Robert Hanson. The incision is made immediately distal to the iliac crest, to the anterior superior iliac spine, thence down the thigh. The tensor and glutaei are loosened extraperiosteally. The latter measure is adopted in order that there may be no risk of jeopardizing the nutrition of the bones after the operation by the periosteum not lying flat against the ilium. The capsule is incised, and the head of the femur is dislocated out of the acetabulum by external rotation and flexion of the thigh. In some cases it is necessary to resect the outer borders of the acetabulum to dislocate the head, and the dislocation can be further facilitated by the use of a strong, round, bowl-shaped scoop which is inserted between the joint surfaces. All capsular tissue should be thoroughly removed with the knife. Fistular passages should be excised and abscesses curetted, if their walls cannot be excised. Sequestra and tuberculous debris are cleared away thoroughly until healthy bone is reached. After cauterization with phenol and alcohol, the head is replaced in its normal position. The muscle, fascia, and skin are carefully sutured. A plaster spica is then applied, including both thighs, with the leg which has been operated upon in a position of 5 to 10 degrees of abduction, about 15 degrees of flexion, and a few degrees of external rotation.

In the early years, inhalation anaesthesia was used, but recently spinal anaesthesia has been the more common method. Before the operation 1,000 milliliters of tutofusin (Ringer's solution) is given intravenously, in order to lessen the shock.

When the operation was performed in the manner described, no serious shock arose in those cases in which the indications for the operation had been correctly appraised. Care must be exercised to prevent the diseased member from becoming adducted when the

FIG. 8-A FIG. 8-B FIG. 8-C

Fig. 8-A: Preoperative roentgenogram, taken Apr. 15, 1943, shows hip of a boy, seventeen years old. The operation was performed four weeks later.
Fig. 8-B: Three and one-half months after operation (Aug. 24, 1943).
Fig. 8-C: Two years and three months after operation (Aug. 29, 1945).

patient is placed on his side for the administration of spinal anaesthesia. Fracture occurred in six cases as the result of lack of caution in this respect. Where massive destruction of the head and neck of the femur had occurred, it was necessary to transplant the trochanter into the acetabulum: and in eleven other cases an extra-articular arthrodesis was done in conjunction with the intra-articular resection.

Observations during Operation

In sixty-three cases an abscess was observed, usually under the tensor fasciae latae, in most cases the result of a rupture of the joint capsule. The joint capsule was thickened, sometimes up to one centimeter, in ninety-one cases. In no patient was the articular cartilage absolutely intact; sequestra were removed from the acetabula in fifty cases and from the head and neck of the femur in twenty-six cases. Perforation from the acetabulum to the pelvis had occurred in thirty-four cases (30 per cent.) and resulted in abscesses of varying sizes, all of which were evacuated.

Subsequent Course

The majority of patients survived the surgical intervention without serious complication. In six cases surgical shock developed, but the patient rapidly recovered after the administration of tutofusin and stimulants. In no case was a blood transfusion used. The wound healed by first intention in sixty-four patients. In twenty-two patients, fistulae developed which persisted to the time of discharge from the Hospital. In eighty cases the temperature dropped to normal within twelve days after operation. The sedimentation rate by the Fahraeus-Westergren method increased directly after the operation in about half of the patients and then returned to normal.

Five patients (4.4 per cent.) died during the three months immediately following the operation. Two of the deaths were the result of tuberculous meningitis*. one of staphylococcic septicaemia, and two resulted from undetermined causes (other than debility from prolonged sepsis).

The duration of the postoperative care averaged six months and ranged up to four years and eight months. The plan of care has been somewhat more conservative in the latter years and, in general, the patients are kept in plaster in bed for three months. with

* One had tuberculous spondylitis and in the other scarlatina developed after the operation.

the diseased member having freedom of knee motion after four weeks. After three months, when the plaster is changed, roentgenographic examination is made; in the majority of cases, it is possible to see that calcification is increasing without advance in the tuberculous process. A new cast is then applied, encasing only the affected side to the knee, to allow the patient to practise walking with the help of crutches.

The point of chief interest in connection with the discharge of the patients is whether ankylosis of the hip joint has been achieved. The patients operated upon have been divided into groups, to facilitate the evaluation of the various methods of operation. Table V shows the number of patients with and without ankylosis at the time of discharge from the Hospital.

Of the 113 patients operated upon, five deaths were classed as postoperative and three deaths subsequently followed,—one at fourteen months after operation from nephrosis, the second nineteen months after operation from tuberculous peritonitis, and the third thirty months after operation from miliary tuberculosis. Death occurred in two other patients after re-admission. Of the 103 remaining patients who were discharged, fifty-three showed ankylosis clinically, but only eight of these showed fusion by roentgenographic examination. The patients were all walking, with weight-bearing on the affected side, when they left the Hospital, and only a few elderly patients required a cane.

There was an average of 3.5 centimeters of real shortening and 3 centimeters of apparent shortening on the affected side. The patients who showed clinical ankylosis had 15 to 20 degrees of flexion, 0 to 20 degrees of abduction (five had adduction of 5 to 20 degrees), and external rotation of 5 to 45 degrees. None of them were complaining of undue pain, and all were satisfied with their results.

Re-Admissions

At varying periods following discharge, eighteen patients returned to the Hospital. Ten returned because of the appearance of fistulae; two had active tuberculosis elsewhere in the body; three required extra-articular fusion; and three required subtrochanteric osteotomies. Death occurred in two of the re-admitted cases.

Result of Follow-up Investigation

During the interval between discharge from the Hospital and the follow-up report, there were four additional deaths: One occurred five years after discharge as a result of meningitis; two patients died of pulmonary tuberculosis nine years and two years, respectively, after discharge; and the fourth patient died of peritonitis, three years after discharge. Information regarding the ninety-nine remaining cases was obtained by examination, questionnaire, or both, and was adequate for this report in all instances except five. It will be noted from Table VI that fusion had occurred, both clinically and roentgenographically, in fifty-eight cases. The fusion had occurred in 5 to 10 degrees of flexion, 5 to 10 degrees of abduction, and 0 to 25 degrees of external rotation. Six patients had draining fistulae. Twenty-one patients had symptoms of mild pain, fatigue, stiffness, limp, or discomfort with weather changes; most of these patients were in the group in which ankylosis had not occurred.

Twenty-eight patients had found it necessary to change their occupations. Six of them were on old-age pensions and the remainder had returned to their original jobs, many of which included hard labor.

DISCUSSION

A radical operation has been described in which an attempt has been made, as far as possible, to remove all tuberculous debris to the extent that this could be recognized by the naked eye. By this operation, the conditions for allowing fusion of the hip to occur have been fulfilled in the majority of cases (Figs. 2-A to 8-C, inclusive). The mortality

rate, which includes the postoperative deaths, as well as the delayed deaths from this form of treatment, is 12.4 per cent., while the number of fusions which occur is only 58.6 per cent.

A number of reasons might be mentioned to explain why fusion was not obtained in more cases. In the earlier period, fusion was not considered desirable, and early passive and active movements were instituted. In some cases the destructive changes in the head of the femur and the acetabulum were so extensive that it was necessary to remove a considerable amount of bone, thus causing the contact between the newly created surfaces to be poor and insufficiently broad to allow fusion to take place. Progression of the process may also be one of the reasons why fusion fails to occur. However, this was not observed in any case in this series.

The author considers this operation to be indicated (1) in those cases where an abscess has developed in the vicinity of the diseased hip; (2) in patients with incipient fistulae in whom secondary infection has not occurred; (3) in those cases where sequestra are to be observed in the head of the femur or the acetabulum; and (4) in any cases showing a tendency to luxation, subluxation, or other malposition, where an operation should be done in all circumstances. This refers, of course, to patients over sixteen years of age. It is necessary to decide each case individually, and this is even more essential when we are dealing with patients with disseminated disease. Caution is especially necessary in patients with pulmonary tuberculosis. Intervention at an early stage in the disease is undoubtedly to be preferred to a resection of necessity in cases with a number of draining sinuses. It is, therefore, desirable that the patients should be sent in for treatment as soon as possible.

If an osseous ankylosis is not achieved, there is always the possibility of being able, at a later date, to do an extra-articular arthrodesis which can then be carried out without consideration for the tuberculous process.

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DISCUSSION

HAMSTRING-TENDON TRANSPLANTATION

(*Continued from page 549*)

tion. Dr. Hough of Springfield, Massachusetts, was in St. Louis last summer and was interested in the results of hamstring transplantations. I saw him three days ago, and he said that, since being in St. Louis, he had checked on hamstring transplantations at his own clinic and had found none that had caused dislocation of the patella. Dr. Fischer found two unsatisfactory results, and apparently there were none in Dr. Vinke's experience.

We did not segregate those cases of lateral displacement of the patella following biceps transplantation which had originally been treated in other clinics, and which had been seen by us after the patella had dislocated. Segregation was not necessary, since the same thing had happened in many of our own cases. In eight of the twenty-nine lateral dislocations of the patella, the patients had had biceps-tendon transplantation alone in clinics other than our own; so we know that other clinics do have similar problems following this procedure. I believe that this is a problem which warrants further checking, with the idea in mind that we are able to prevent the chief cause of failures.

INTERNAL FIXATION FOR LUMBOSACRAL FUSION *

BY DON KING, M.D., SAN FRANCISCO, CALIFORNIA

From the Division of Bone and Joint Surgery, Department of Surgery, Stanford University Medical School, San Francisco

Although some difference of opinion may exist about the indications for lumbosacral fusion, there can be no doubt about the effectiveness of the operation in properly selected cases. Its field of usefulness is large, and, if the prolonged period of postoperative fixation in plaster could be eliminated, many more patients would take advantage of this operative procedure.

During the past eight years we have been using metal screws through the lateral articulations, with the idea of securing rigid internal fixation at the time of the operation and thereby eliminating the necessity for prolonged immobilization in plaster. This

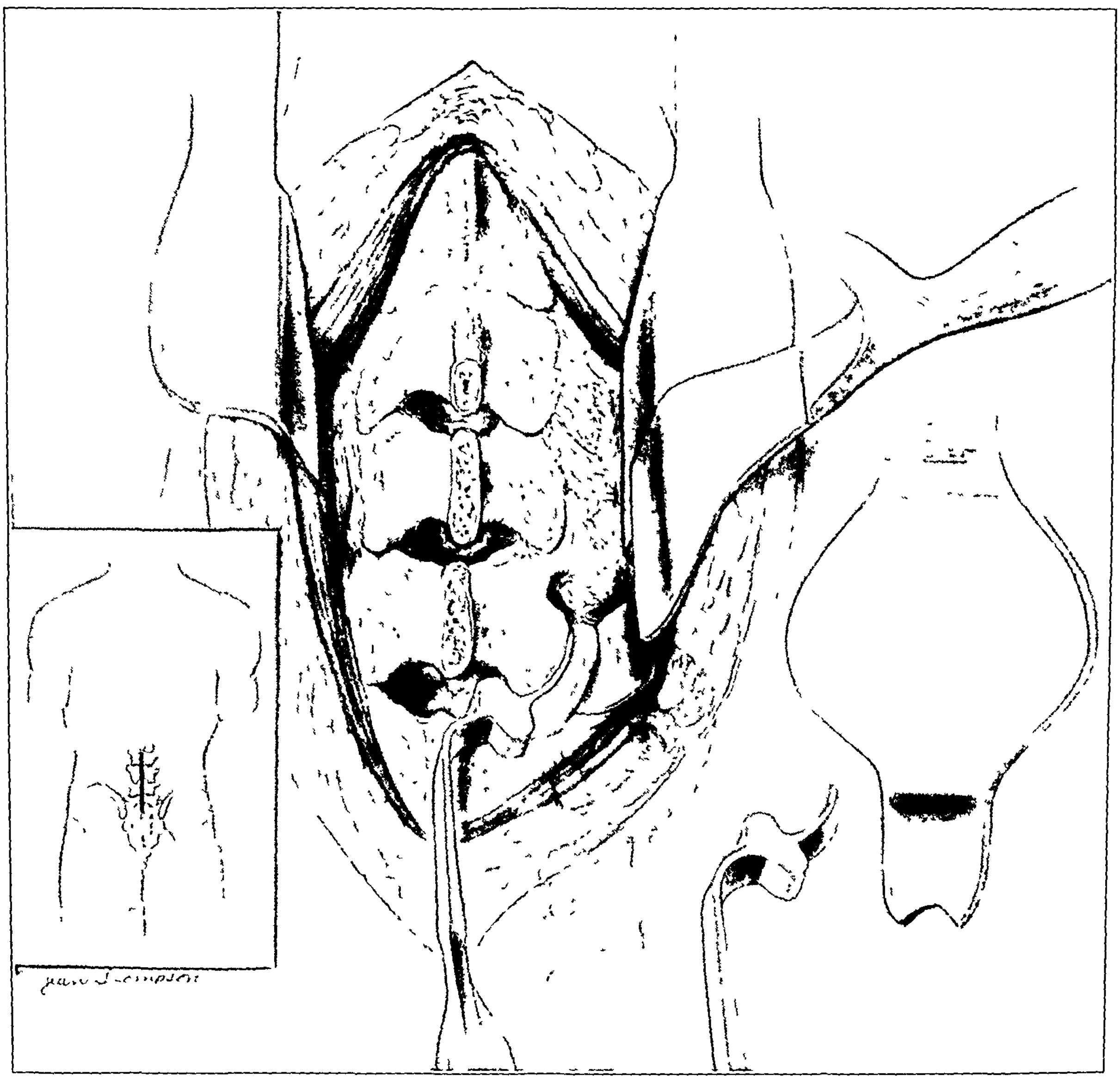

FIG. 1

Illustrates use of notched Bennett retractor for exposure of lateral articulations, and special osteotome for removal of articular cartilages.

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 27, 1947.

FIG. 2
Showing insertion of drill point and screw.

operation has been quite satisfactory, and the primary purpose of this paper is to describe the technique and to report the present condition of forty-four patients who were operated upon during the years 1940 to 1945.

OPERATIVE TECHNIQUE *

The local supply of bone is supplemented with bone grafts from either the tibia or the ilium, the ilium being preferred. To facilitate removal of the iliac graft, the operation is started with the patient in the three-quarters-prone position, so that the anterior half of the iliac crest and the lumbosacral area can be exposed simultaneously through the hole in a Caesarean drape sheet. The incision for removal of the bone graft begins at the anterosuperior spine and extends backward along the anterior half of the iliac crest for about five inches (thirteen centimeters); here the crest is widest and practically subcutaneous. A large quantity of cancellous bone is immediately available and can be obtained in long slices, chips, or in a single piece, as the surgeon desires. The wound is closed, the sandbags are removed, and the patient is allowed to assume the fully prone position.

Through a mid-line incision, the muscles are reflected from the spinous processes and laminae in the usual way. Exposure of the lateral articulations is greatly facilitated by the use of Bennett retractors with notched tips (Fig. 1). The notched tip of the retractor is placed against the lateral mass of the first sacral vertebra, just lateral to the sacral facet.

* The technique is described for a single joint fusion,—lumbosacral.

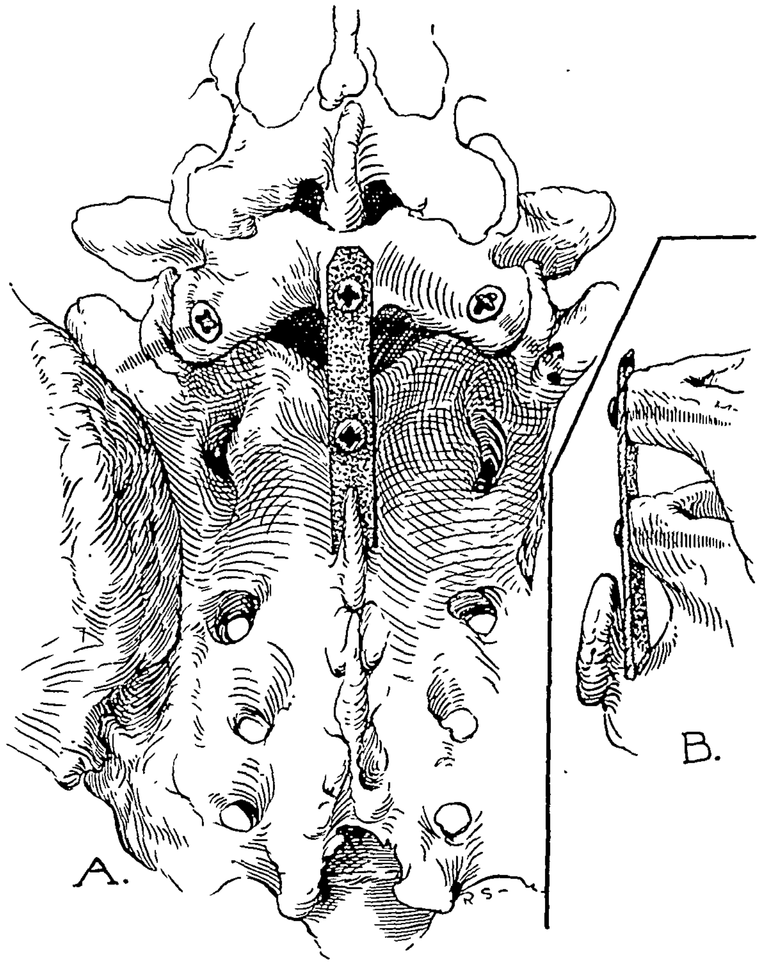

FIG. 3
Tibial graft fastened to tips of spinous processes.

With this point as a fulcrum, the handle of the retractor is pressed outward (lateralward) so that its broad body fits snugly against the muscle, keeping it out of the way. By this means a satisfactory exposure of the lateral articulation is obtained, for removal of its articular cartilage. For this purpose we have used a Smith-Petersen curved osteotome, one-half inch wide, with the terminal end reshaped and hilted to fit the curve of the average lateral articulation (Fig. 1). The fifth lumbar spinous process is removed, and a small notch is made in the middle of the cortical surface of the articular facet for the reception of a drill point. This is necessary to prevent "wandering" of the drill point when it begins to rotate. The drill (a No. 31 drill point being used) is directed downward and outward, parallel to the inferior edge of the lamina (Fig. 2), at an angle of 45 degrees. The drill passes through the two facets of the articulation, making a tunnel for the insertion of the screw. (For women, a screw three-quarters of an inch in length is used; for men, one inch.) After the screws have been inserted and tightened, the rigidity of fixation can be tested by seizing the stump of the spinous process with a bone-holding forceps and lifting toward the ceiling. The sacrum and the fifth lumbar vertebra now move together.

The remainder of the operation consists in elevating multiple small grafts from the fifth-lumbar laminae and sacrum, and arranging the tibial or iliac grafts against the raw osseous surfaces thus produced. In a few cases in which the spinous processes were well developed, a tibial graft has been fastened to them with small screws (Fig. 3). The wound is closed with a soft rubber drain, which is left in place for two days.

Postoperative Care

After the operation the patient is placed in a board-reinforced bed, and he is urged to turn himself from time to time. This is painful during the first three days. Fifty thousand units of penicillin each three hours are given for seven days. Although patients can get up and walk in a few days, they are encouraged to stay in bed for three weeks.

There are two indications for postoperative bracing. First, if the patient has used a brace for a period of months or years before the operation, he should continue with his brace until fusion is solid and exercises can be started. The second indication is in an occasional case in which absolutely rigid fixation has not been secured. In such cases, we have used a chair type of lumbosacral brace.

Variations in Operative Technique

As mentioned previously, bone grafts from the tibia have been used in some cases.

In some patients with well-developed spinous processes, we have placed a tibial graft directly on top of the spinous processes of the fifth lumbar and first sacral vertebrae, and fastened the graft directly to them with screws (Fig. 3). On several occasions, particularly in cases where there has been a transitional type of fifth lumbar vertebra and one of the lateral articulations has not been well developed, a screw has been used only on one side. Needless to say, the operative technique has been used on a number of occasions in conjunction with the removal of displaced portions of the intervertebral disc.

Dissecting-Room Experiment

In contemplating the use of screws through the lateral articulations, one naturally wonders if the facet is really large enough to admit a screw without danger of fracture of the facet through the screw hole, particularly after the patient becomes ambulatory and the bone is subjected to the stresses and strains of motion. In an effort to determine this point, screws were placed through the lateral articulations of fresh cadavera. It was found that when a hook was placed under the laminae of the fifth lumbar vertebra, and traction was applied to this hook through a ceiling pulley, fracture of the lateral articulations did not result. A review of this series of cases did not disclose a single fracture of a facet.

Fig. 4-A

W. M. Six years after operation.

Complications

In the entire series of fifty-five cases, there were two cases of wound infection which

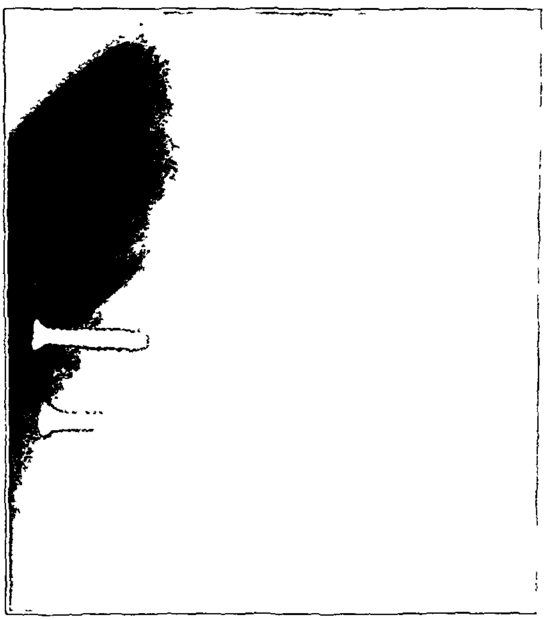

Fig. 4-B

Fig. 4-C

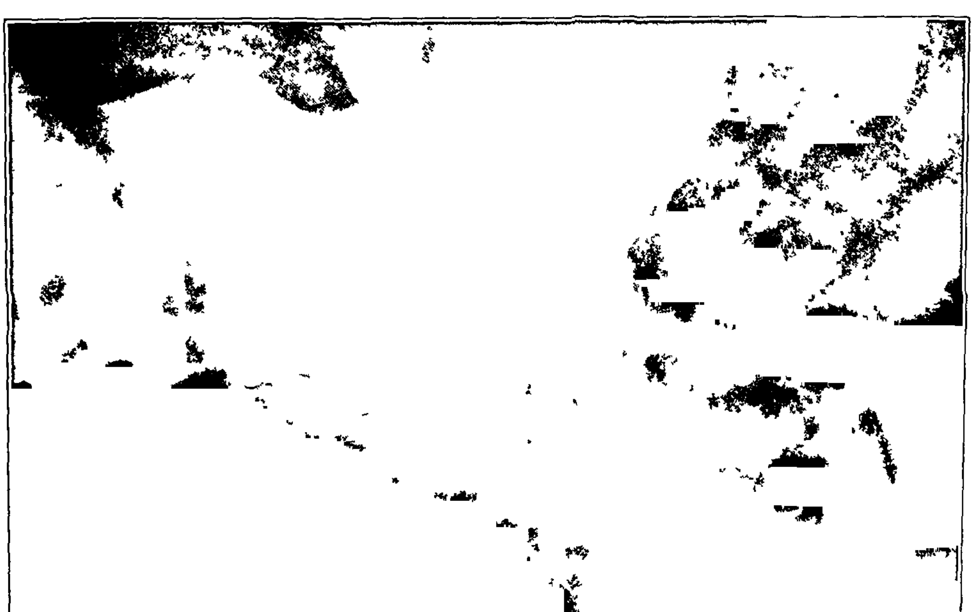

Fig. 5-A

Fig. 5-B

Fig. 5-C

D. H. Oblique and lateral views, four years after operation.

necessitated removal of the screws, one postoperative atelectasis, and one case of mild thrombophlebitis. In one patient, definite nerve-root irritation resulted from one of the screws, which had to be removed. No deaths occurred in this series.

Sex and Age

Twenty-three of the patients were males and twenty-one were females. The youngest patient was eighteen years of age and the oldest was fifty-eight years; the average age was thirty-seven.

Roentgenographic Findings

The roentgenographic findings were negative in fourteen cases. A thin disc was present in twelve, a transitional vertebra in twelve, and evidence of arthritis in six.

RESULTS

Although fifty-five of these operations were performed during the six-year period from 1940 to 1945, we were able to establish contact with and to examine only forty-four of the patients. All of these patients were subjected both to clinical and roentgenographic investigation. When there was any question about whether a solid posterior bridge was present, the roentgenographic investigations were carried out with the patient in forward flexion and in extension. Of the forty-four patients, pseudarthrosis was definitely present in four or 9.1 per cent. Interestingly enough, only one of these four patients with pseudarthrosis complained of pain in the back or felt that he did not have a satisfactory result from his operation. In this small series, therefore, there was not a very close correlation between pseudarthrosis and function, as three of these patients had excellent functional results. In addition to this one patient with pseudarthrosis who had a poor functional result, three others had poor functional results, although each had a perfectly solid bony fusion, including disappearance of the lateral articulations. In short, the results in the forty-four cases show solid bony fusions in forty or 90.9 per cent., an incidence of pseudarthrosis of approximately 10 per cent., and about 10 per cent. with poor functional results.

SUMMARY

By the placement of screws through the lateral articulations, rigid internal fixation can be secured in the lumbar spine-fusion operation. The position in which the joint is to be ankylosed can be accurately controlled, and the necessity for prolonged immobilization in plaster is eliminated. Forty (90 per cent.) of forty-four patients operated upon have solid bony fusion after two to seven years. The osseous fusion develops slowly while the patient is ambulatory.

DISCUSSION

Dr. Lenox D. Baker, Durham, North Carolina: This end-result study of the use of internal fixation of the articular facets in spine fusion is a most valuable contribution to spine surgery, and Dr. King is to be congratulated on developing this adjunct to the Hibbs fusion. In his paper, Dr. King makes it clear that the use of the screws is not recommended except as an adjunct, and he emphasizes the importance of bone fusion.

Since Dr. King's preliminary report describing the operative procedure, we have used interfacet Vitallium screws in 108 spine fusions. It has been our impression that the patients are more comfortable during the postoperative stage, are able to be ambulatory at an earlier date, have less postoperative distention, and are less likely to have other postoperative complications, such as thrombophlebitis, et cetera. Again, I congratulate Dr. King and thank him for a sound and useful contribution.

Dr. Alan DeForest Smith, New York, N. Y.: The desirability of internal fixation in these operations is quite evident. Several different methods for accomplishing this have been suggested, of which I believe that described by Dr. King is the best. He was the originator of the procedure and the first to use it; but

(*Continued on page 578*)

MUSCULAR TORTICOLLIS *

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS

Congenital muscular torticollis is a condition that is recognized and well understood by members of this Association, and it may be a bit presumptuous to open this topic for general consideration. The treatment of this condition, although varied, is as standardized as that of any well-known pathological entity encountered by the orthopaedic surgeon. Correction of persistent deformity by surgical measures is a recognized procedure. It has been carried out in a large number of cases by every surgeon in this audience. Orthopaedic texts are in general accord as to the characteristics of the primary and secondary deformities of muscular torticollis and as to the need for securing the maximum correction, chiefly by surgical means, before skeletal maturity. Little is said concerning the optimum time for surgery or the more detailed management of the case. Long series of cases, recorded by many careful observers, attest to the efficiency of the treatment, for the results are, on the whole, very satisfactory.

A dearth of papers on muscular torticollis in the orthopaedic literature of the past fifteen to twenty years would seem to indicate the static position of the subject. During this time, a new generation of orthopaedic surgeons has come to the front. Textbook concepts of muscular torticollis are reflected with great accuracy during the course of interviews which are a part of the examination of the American Board of Orthopaedic Surgeons. These concepts are fortified by varied personal experiences, and the subject is dismissed. With rare exceptions, orthopaedic texts or chapters in monographic texts refer to the etiology of muscular torticollis as birth trauma of the sternocleidomastoid, with hematoma formation and with subsequent resorption of the hemorrhage or replacement of the tumor with scar tissue. The high incidence of breech and abnormal deliveries is emphasized. That a prenatal contracture of the sternocleidomastoid may exist is recognized.

I quote from an early text by the then Professors of Pediatrics of Columbia and Johns Hopkins Universities, Dr. L. Emmett Holt and Dr. John Howland, respectively: "Hematoma of the sternomastoid muscle leads to the formation of a tumor in the belly of the muscle. It is a rather rare condition, usually noticed in the second or third week of life, and it disappears spontaneously, rarely causing any permanent deformity. The tumor varies from three-quarters of an inch to one inch and a half in length, being about the size and shape of a pigeon's egg. It is movable, almost cartilaginous to the touch, and sometimes slightly tender. The situation of the tumor is usually about the center of the muscle. There is no discoloration of the skin.

"In about two-thirds of the cases it occurs after breech presentations. It is much more frequent upon the right than upon the left side. In twenty-seven cases collected by Henoch, the right side was involved in twenty-one and the left in only six cases. The explanation of this difference is to be found in the obstetrical position. Rarely, both sides may be involved. The head is usually slightly inclined toward the shoulder of the affected side and rotated toward the opposite side. The swelling slowly diminishes in size, and in most cases by the end of the third month has nearly or quite disappeared. Occasionally a slight torticollis remains for a longer time, but in the majority of cases the recovery is perfect. Hematoma of the sternomastoid is due to the twisting of the head during parturition. It is not an evidence of the employment of any improper force in delivery. The twisting of the head produces laceration of some of the blood vessels of the muscle and in some cases there is doubtless rupture of some of the fibers of the muscle itself. Following this there occurs a certain amount of inflammation of the muscle and its sheath. The tumor is due

* Presented at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 29, 1947.

partly to blood extravasation and partly to inflammatory products. In one or two recent cases in which the sheath of the muscle has been opened it has been found filled with blood.

"The condition requires no treatment. Operative interference is positively contraindicated."

Elsewhere in the same text, the authors state: "An old case of torticollis is a serious matter and radical measures should be resorted to early in the disease".

More recently Shands, in his excellent and popular *Handbook of Orthopaedic Surgery*, states: "It has been thought by some observers that the pathogenesis is rupture of many of the muscle fibers during birth, with the formation of a hematoma and subsequent replacement of part of the muscle by scar tissue. Hematoma of the sternocleidomastoid muscle is sometimes observed in the newborn infant; it forms a nontender cylindrical tumor which usually regresses slowly in from three to six months. Incomplete regression of the hematoma may be followed by the development of a contracture of the sternocleidomastoid muscle."

Robert W. Johnson, Jr., writing in Christopher's *A Textbook of Surgery*, says: "The muscle may become contracted in utero or may undergo fibrosis and shortening secondary to stretching and tearing during delivery. In many cases a hematoma in the muscle can be palpated in the first week."

Christian, in Osler's book, states: "In congenital wry-neck the sternomastoid is shortened, hard and firm and in a condition of more or less advanced atrophy. This must be distinguished from the local thickening in the sternomastoid due to rupture, which may occur at birth and produce an induration."

The foregoing quotations represent a fair cross section of source material relating to the pathology of muscular torticollis. Concerning the significance of tumors in the sternocleidomastoid, discussions with many pediatricians of wide clinical experience would indicate that such tumors are undoubtedly hematomata, are of little or no significance, and leave no lasting defect. To suggest any other opinion always precipitates a heated argument.

The cases of muscular torticollis seen by the orthopaedic surgeon permit a different perspective on the significance of early muscle changes. In a paper published in 1944 by Chandler and Altenberg, 101 cases of muscular torticollis were analyzed. In order to present a somewhat wider concept of the problem, these cases are now combined with a group of 124 patients with muscular torticollis who have been operated upon at the University of Illinois since 1938 and in private practice since 1943. This makes a total of 225 patients. Of these, 109 were males and 116 females. The right side was involved in 127 instances and the left side in 98. The age of the patient at time of operation ranged from three weeks to seventeen years. Forty-two patients were under one year of age. Of these, twenty-six were less than four months old; the youngest was three weeks of age.

Birth histories are important, but in this combined series they are relatively inaccurate, especially in the older group. In the infant group, where more details are available, a history of breech presentation is encountered in about 50 per cent. The number of difficult deliveries of other presentations is high. Three infants were delivered by Caesarean operation.

The high incidence of breech presentations in cases of muscular torticollis is of particular significance, for a direct relationship between the deformity and the abnormal presentation probably exists. Of the various textbooks on obstetrics reviewed, the only reference to torticollis as a factor in breech presentation was made in the latest edition of De Lee and Greenhill's *Obstetrics*. In this text, our previous publication was quoted at length. The high incidence of breech deliveries in cases of muscular torticollis has been stressed by many others writing on this subject. Obstetrical literature reflects an increasing interest in the relationship of prenatal posture to various deformities,—an observation well established among orthopaedic surgeons. The high incidence of breech presentations

adds weight to the well-recognized concept of prenatal pathological changes in the sternocleidomastoid.

The group of infants under four months of age are of particular interest. The torticollis in some was noted soon after delivery, but the tumor of the sternocleidomastoid was not recognized until the tenth to fourteenth day after birth. The tumor increased in size for the next three to five weeks, and then slowly receded at varying rates, occasionally persisting for months. This tumor is smooth, attached to the deeper structures, and freely movable beneath the skin and on the underlying cervical spine. It is tense, semi-elastic, and apparently tender to pressure. Separate tumors may involve both portions of the muscle. There is no induration of the soft parts adjacent to the tumor; and in none of the cases in this report was there any ecchymosis of the overlying skin. Erb's palsy occurred three times, once on the same side as the tumor and twice on the opposite side.

The various theories advanced to explain the development of the tumor mass have been presented in our previous publication. In that article, conclusions as to the origin of the tumor were as follows: "We believe, therefore, that intrauterine malposition, and the possible pressure and ischemia which may result in the sternocleidomastoid muscle therefrom, contribute to the cause of muscular torticollis by rendering the muscle definitely atrophic, maldeveloped, fibrous, shortened, and ischemic. These changes may well cause the muscle in some cases to be liable to damage with a traumatic or even a normal delivery, which would not damage the normal sternocleidomastoid muscle."

Operations performed for the correction of torticollis in this entire series varied in type according to age. In the older patients, detachment of the sternal and clavicular heads of the sternocleidomastoid, followed by retention of the muscle in an overcorrected position, gave satisfactory results. The employment of a stretching sling over the shoulder and incorporated into the cast was found to be most advantageous. In the group of forty-two infants, excision of the tumor mass was carried out. This procedure is not a serious one, but must be done in such a way that the other structures of the neck, especially the spinal accessory nerve, are not damaged. This nerve should be identified and disengaged from the tumor. The nerve is a small structure, which usually passes between the bellies of the cleido-occipital portion of the muscle in the middle third. Considerable variation in its position has been encountered. Hemostasis is most essential. Closure of the wound is accomplished by deep suture with plain catgut and subcuticular suture of the skin. To obliterate any dead space, a pressure dressing is applied. A light plaster splint, which maintains overcorrection, is worn for three or four weeks. This is followed by gentle stretching of the muscle, which can be performed by the patient's mother.

A study of the excised tumors is of interest,—especially that of tumors removed within the first few weeks of the infant's life. These tumors consist of fusiform masses, involving part or all of the muscle belly of the sternocleidomastoid, usually in its middle third. The tumor is limited by the perimysium and may extend proximally and distally to involve the entire muscle substance. It is firm in consistency and separates readily from adjacent structures. Cross section reveals a white, fibrocartilaginous, glistening surface, which at times is slightly lobulated. In none of the specimens was there anything to suggest blood-clot formation or residual blood pigment. Microscopic sections show muscle fibers in all stages of degeneration, as reflected by their wide variations in staining qualities. Fibrous tissue is abundant, replacing muscle fibers to varying degrees. Occasionally, normal muscle fibers survive. These are usually at the periphery of the fibrous mass. No evidence of hemorrhage or residual hemosiderin was present, even in specimens removed in the earliest weeks of the patient's life. The over-all pathological process appears to be that of the replacement of muscle tissue by fibroblasts, which develop in great profusion to form the tumor mass. This may be likened, in some respects, to the great excess of callus frequently found at the site of birth fractures. In older patients, the tumor has disappeared, leaving a firm inelastic band, which replaces part or all of the normal muscle.

The results of the surgical correction of muscular torticollis are probably the most positive of those obtained from any orthopaedic procedure, provided the operation is done at an age that will permit remolding of the skeletal structures. The justification of surgery in very young infants may be debatable, but our uniformly good results, and the prevention of the more fixed secondary skeletal deformities, lead us to the conclusion that early operation is indicated.

A wider experience with early operation by members of this Association will clarify the indications and contra-indications for such a course.

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DISCUSSION

DR. J. HIRAM KITE, ATLANTA, GEORGIA: After several years of programs devoted to war surgery, I am pleased to see congenital deformities back on the program.

I want to thank Dr. Chandler for taking up a subject that is "static", as he expressed it, and giving us so many new facts about it. He has changed the name from "congenital" to "muscular" torticollis.

We have been told by the authorities in the past that the tumor was due to a hemorrhage in the muscle, and we have accepted this, even though we have never seen any discoloration of the skin. Dr. Chandler has shown that in none of his patients, not even in the three-week-old baby, were there any signs of intramuscular hemorrhage, nor was hemosiderin to be found upon microscopic examination.

Nové-Josserand and Viannay thought that the condition was due to an ischaemia. They stated that the middle part of the sternocleidomastoid was supplied with blood by an "end artery", and they noted that in every case of wryneck the lumen of the sternomastoid artery had been obliterated at the anterior border of the muscle. Chandler has shown in his dissections that the muscle is supplied by several arteries, and that there was bleeding from all when he dissected out the tumor.

It has been claimed that the trauma of labor causes a temporary acute obstruction of the veins, followed by a fibrous-tissue change similar to the mechanism which produces contracture of the flexor tendons of the forearm in Volkmann's ischaemic contracture. Chandler has shown that the venous drainage of the sternocleidomastoid empties into all the major veins of the neck. He has shown a profuse communication in the muscle with at least eight major veins, so it is difficult to believe that there can be a venous stasis.

Of the 225 cases reviewed, forty-two of the patients, or nearly one-fifth, were under one year of age. Twenty-six, or more than 10 per cent., were under four months of age. I have not dissected out the tumor in any patients of this type. In the past, we have been told by our best authorities that the condition requires no treatment, and that operative interference is positively contra-indicated. This may be another "error" which has been handed down, but since there is a good probability that many of these tumors will clear up spontaneously, I am still inclined to give Nature a chance.

As to the operative procedure, I used to employ general anaesthesia in all of my cases, but for the last few years I have done them under local anaesthesia. I feel that it is necessary to apply a form of fixation that will keep the head rotated in the opposite direction until the muscle has healed, and, therefore, I have used a plaster jacket. This can be more easily applied if the patient is awake and not nauseated.

My poorest results have occurred in cases where the head rotated in the jacket and turned back toward its original position; so I think the postoperative treatment is as important as a thorough division of both heads of the muscle.

DR. ROBERT V. FUNSTEN, CHARLOTTESVILLE, VIRGINIA: Dr. Chandler has presented an old subject in a very interesting way, and has added a new approach to the treatment of muscular torticollis. Never having attempted surgical removal of the tumor mass, and never having done surgical correction in a child under one year of age, I am not sure I can agree with him on the advantage or necessity of this procedure, but

(Continued on page 588)

CORACOCLAVICULAR JOINT

Surgical Treatment of a Painful Syndrome Caused by an Anomalous Joint

BY LUIZ GUSTAVO WERTHEIMER, M.D., SÃO PAULO, BRASIL

*From the Clínica Ortopédica e Traumatológica *, Hospital das Clínicas da Faculdade de Medicina, Universidade de São Paulo*

In the normal human skeleton, the bones of the shoulder girdle are joined together by the acromioclavicular articulation and by the trapezoid and conoid ligaments, which go from the inferior surface of the lateral third of the clavicle to the body of the coracoid process. These coracoclavicular ligaments help to unite the clavicle and scapula and, with their form and elasticity, they allow a certain degree of dislocation between these bones in movements that have as centers the acromioclavicular and sternoclavicular articulations.

Occasionally, however, we find an articular formation which joins the two bones of the scapular girdle, substituting for the trapezoid and conoid ligaments the "articulus coracoclavicularis".

Incidence of the Coracoclavicular Joint

Comparatively few cases of this condition have been reported in the literature. Until 1900, the only cases published were reported by Gruber, Luschka, and Fick. From a research of all literature up to this year, the author was able to record cases reported by the following authors:

A. With roentgenographic proof: Frassetto (three cases), Possati, Giongo, Pigorini, Pondé and Silveira, Agati, Ikeda, Timpano (four cases), Longhi, Gradoyevitch, Alarcón, Figueiredo, Slocum, Nutter (twelve cases), and del Valle and Giordano. These cases, plus the two cases reported here, made a total of thirty-three with roentgenographic confirmation.

B. With necropsy confirmation: Poirier (three cases), Fick (two cases), Gruber, Luschka, Jeanneney and Celles, Gowland, Testut (three cases), Monteiro, Lane, Ponthus and Boudènes, Miessen, and Schlyvitch. There were, therefore, seventeen cases which had been proved anatomically.

This gives a known total of fifty cases up to the present. Publications have appeared about the ossification of the coracoclavicular-joint ligaments, as those of Hartmann (1887), Robineau (1897), and Ribet (1931), the latter with three observations in eighty scapulae. These cases of pathological ossification of the coracoclavicular ligaments are not to be confused with those of a true joint.

Clinical Significance of the Coracoclavicular Joint

The coracoclavicular joint has occasionally been seen at the dissection table or on roentgenograms. We must distinguish the chance discoveries on roentgenograms, taken for another reason unrelated to the anomalous articulation, from those in which pain in this region directly indicated roentgenographic examination.

The chance discoveries are more frequent and the authors, with the exception of Frassetto, do not refer to any symptoms caused by the anomalous articulation. Frassetto cited the case of a woman with a bilateral coracoclavicular joint, who had fractured the surgical necks of both humeri in two accidents; in his opinion, the coracoclavicular articulation predisposed to the fracture of the neck of the humerus.

The coracoclavicular joint caused symptoms in only a few cases. Possati found signs of osteo-arthritis in the coracoclavicular joint and in the other surrounding joints in a

* Prof. F. E. Godoy Moreira, Director.

workman, sixty-three years old, who suffered from pain and limitation of shoulder movements. Del Valle and Giordano observed a woman of thirty-five with a painful cervicobrachial syndrome which improved after resection of the coracoclavicular joint.

The first of our patients was also a workman, with pain and limitation of the shoulder-joint movements, who improved after resection of the coracoclavicular articulation. He was a male negro, aged thirty-seven, who complained that pain in the shoulder had been present for the last three years. The patient stated that, while working as a rock digger, his arm was suddenly forced into motion, as a stone that supported his lever slipped off unexpectedly. Until then he had had all the movements of the shoulder, and had had no complaints.

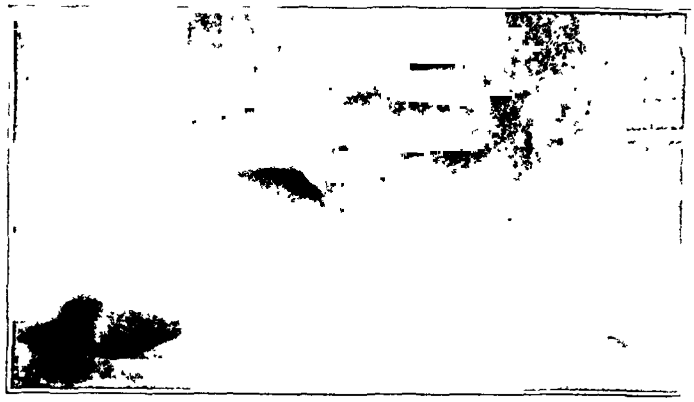

Fig. 1

Roentgenogram of shoulder shows osseous overgrowth at juncture of distal and medial portions of the clavicle, directed downward and outward, with an enlarged downward and inward border. Another osseous overgrowth is present at the base of the coracoid: this articular surface is adjusted to the clavicle, with a joint space of three millimeters.

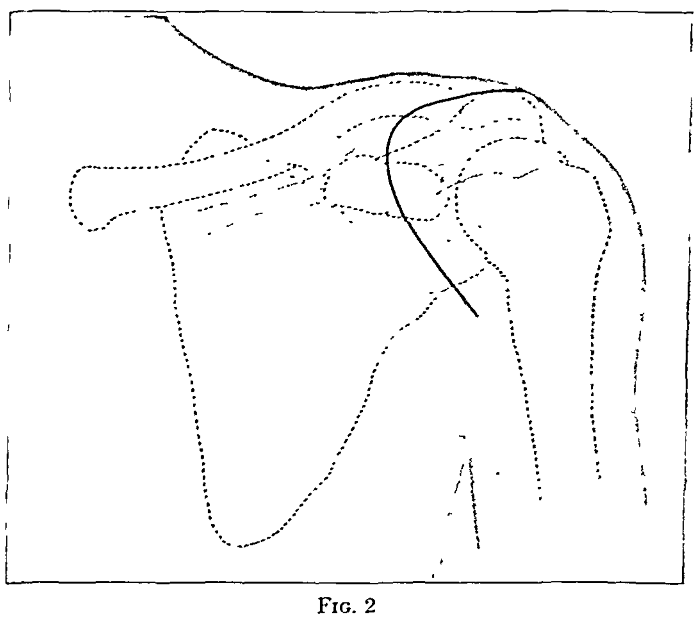

Fig. 2

Skin incision and skeletal relationship. The vertical incision is along the deltoid-pectoral groove, and the horizontal incision is along the lateral third of the clavicle.

Since this accident, three years before, the patient had begun to feel continuous pain in the shoulder, increasing with any movement. The pain was continuous, radiating to the arm, persisting during rest, and increasing with exercise. The shoulder movements became limited as a result of the pain, and the patient had not worked for two years. He was treated with massage and injections without relief.

Examination of the active movements of the left shoulder revealed that abduction could be made without pain as far as 45 degrees, and it was possible up to 80 degrees with severe pain. Flexion was not painful up to 60 degrees; extension was normal: external rotation was painful; internal rotation was normal and not painful. Palpation caused pain in the deltoid area. A neurological examination was negative.

The roentgenograms did not show any local alteration, except an anomalous coracoclavicular joint (Fig. 1); a bony projection, one centimeter long, arose from the site of union of the middle and lateral thirds of the clavicle and was directed downward and outward. It was slightly enlarged at its free end, which was directed downward and

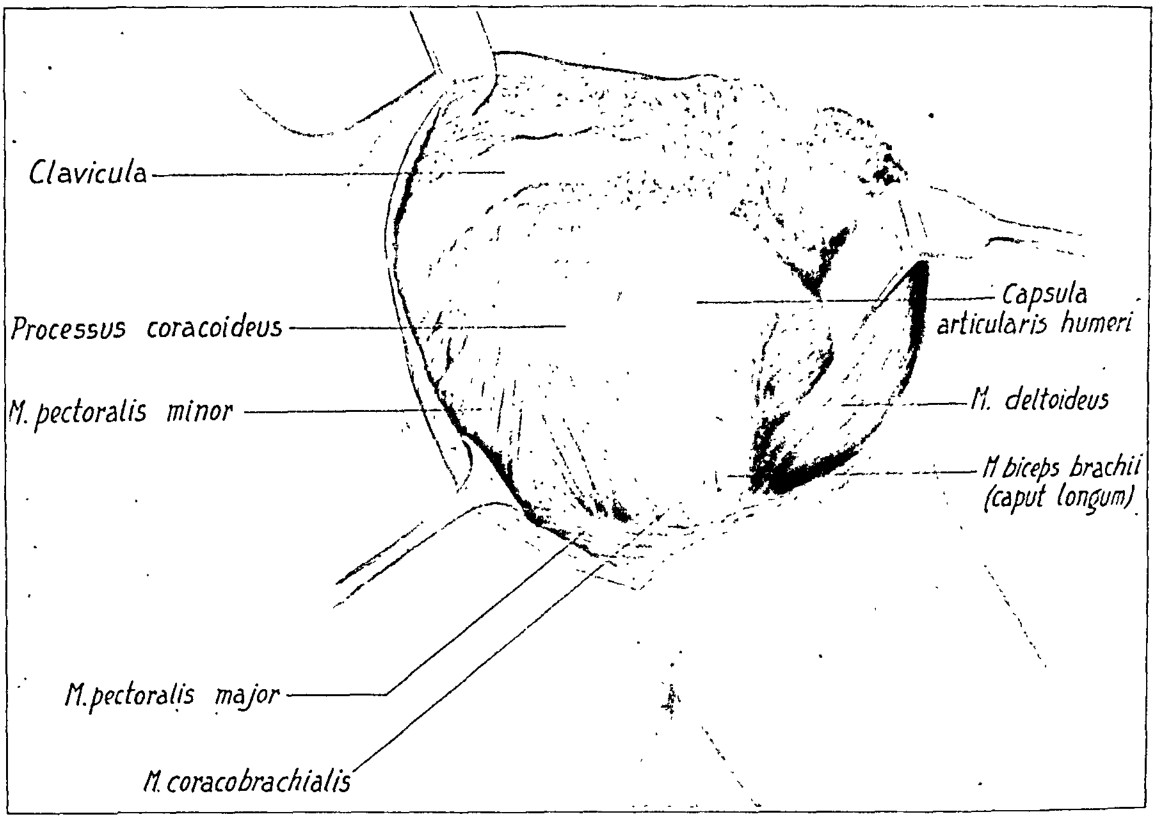

FIG. 3

Deltoid detached at clavicle and swinging outward. There is clear exposure of lateral third of clavicle, pectoralis minor and coracobrachial attachment, scapulohumeral capsule, and long biceps tendon. Note the fat tissue between clavicle and coracoid process.

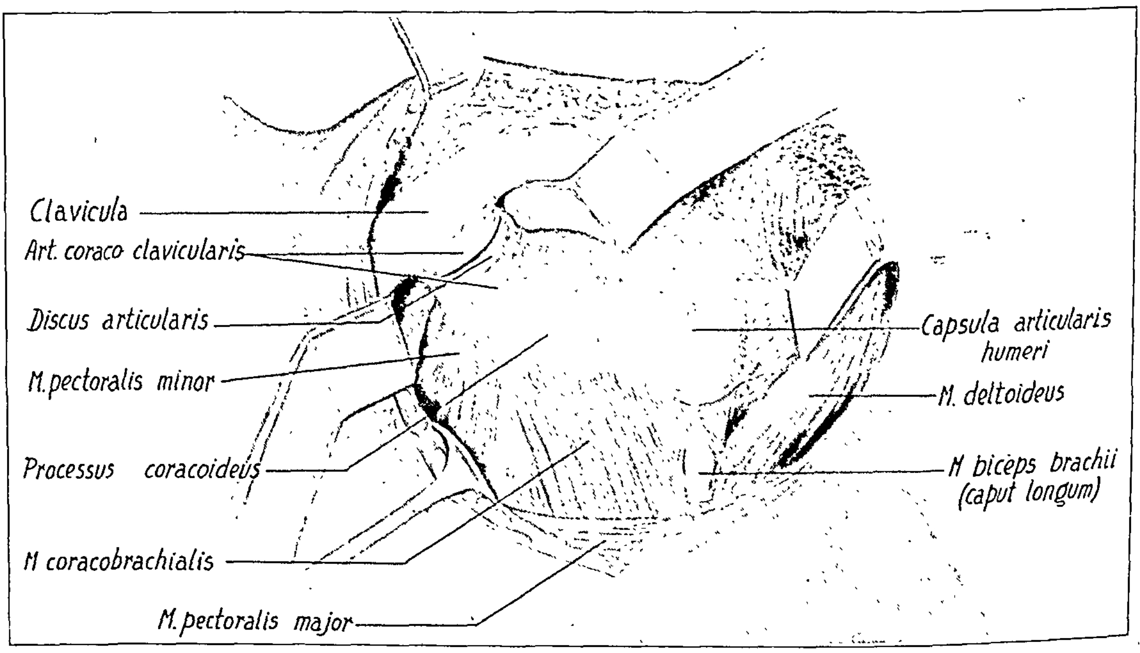

FIG. 4

After excision of the fat tissue, we find fibrous bands. After excision of the fibrous bands, the joint is shown. Between the osseous overgrowth we see an intra-articular disc, with the superior surface free and smooth and the inferior surface rough and partially adherent.

inward. At the base of the coracoid process was a formation directed toward the clavicular process, with which its free surface adjusted exactly, and from which it was separated by a space of three millimeters. Roentgenograms of the opposite side did not show the existence of a similar anomaly.

Prolonged physiotherapy was carried out; it consisted mainly of heat, massage, and

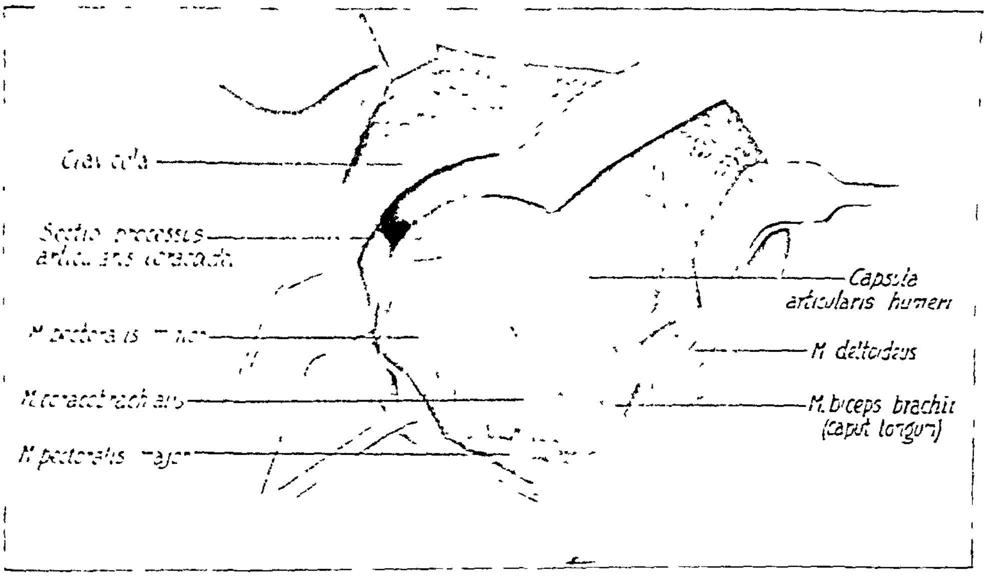

FIG. 5

After removal of the disc, an osteotomy of the anomalous overgrowth is performed, emptying the space between the clavicle and the coracoid process.

movement, alternated with periods of rest. A year later the patient was in the same condition, complaining of constant pain which had prevented him from working for two years, so that resection of the anomalous joint was decided upon.

Operation

An incision of fifteen centimeters (six inches) was made over the deltoid-pectoral fold, from the clavicle to the anterior axillary fold (Fig. 2); the cranial end of this incision was prolonged outward, over the clavicle, to an extent of six centimeters. The superficial layers were dissected as far as the pectoral fascia. The deltoid muscle was detached from the clavicle; the muscle was then turned outward (Fig. 3). Large exposure was made of the pectoralis minor and coracobrachialis muscles, on the apex of the coracoid process, and of the pectoralis major and the capsule of the scapulohumeral joint, with the tendon of the long head of the biceps. A mass of fat tissue was found, filling the subclavicular space. When this had been removed, at certain points fibrous tissue was seen, forming bands resembling a true ligament; after excision of that tissue, a bone formation appeared at the union of the lateral and middle thirds of the clavicle, joining its inferior surface with the base of the coracoid process (Fig. 4). The scalpel cut through a space between the two processes and showed a smooth, shining surface turned upward, which was recognized as the superior surface of an interarticular disc. When attempts were made to remove this disc, it was found to be partially attached to the rough superior surface of the base of the coracoid exostosis.

An osteotomy of the two joining processes was performed (Fig. 5). The same fibrous bands described on the anterior surface were seen, corresponding to the posterior surface of the pre-existing articulation, and more extensive. Reconstruction of the different layers was carried out, and a dressing and bandage were applied and continued for eight days.

Postoperative Course

The skin sutures were removed after eight days, and active movements were started. When the patient was examined, three months after operation, he was free from pain, movements had become unrestricted, and it was possible for him to join his hands over his head with his arms fully extended.

FIG. 6

Section of clavicular process shows spongy bone tissue, consisting of wide lacunae filled with bone marrow and covered by a thin layer of bone tissue; this is covered by a fairly thick layer of fibrous cartilage.

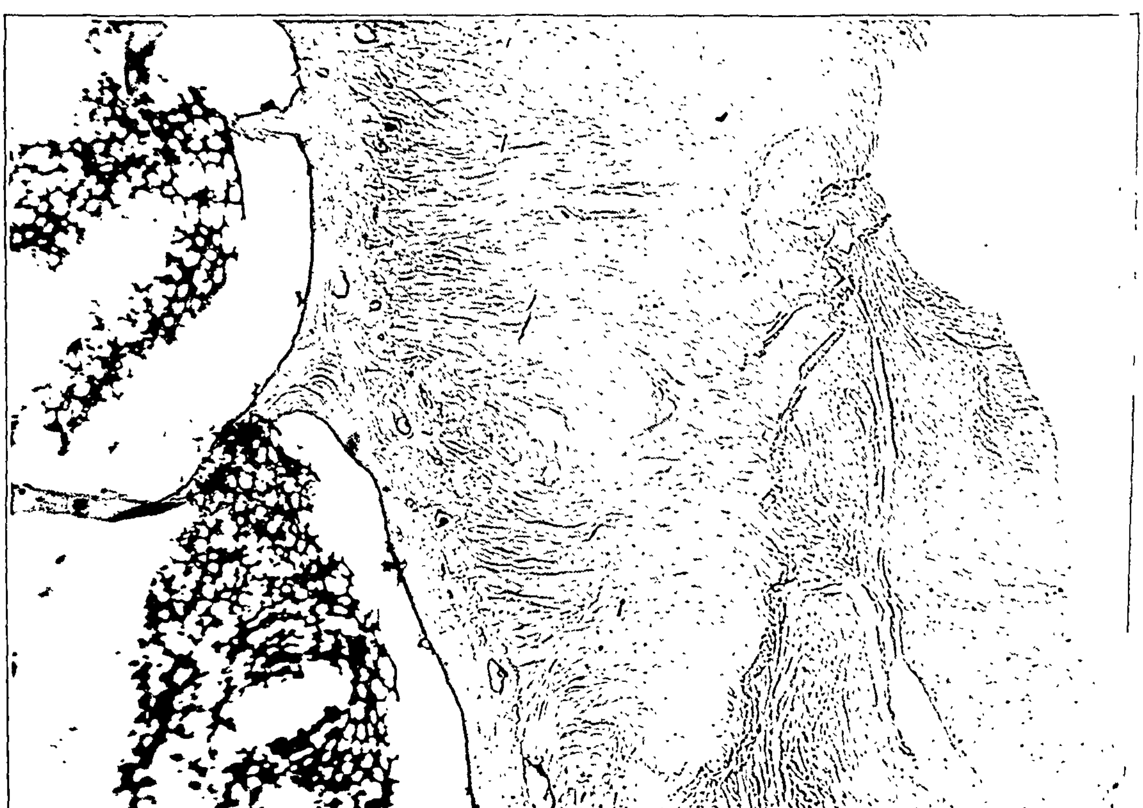

FIG. 7

Section of the coracoid exostosis shows the same arrangement, except that the layer of compact bone tissue is thicker and has a typical Haversian system. The covering cartilage presents fibrillation.

FIG. 8
Section through entire thickness of the articular disc reveals fibrocartilaginous arrangement.

Histological Examination of the Articular Formation *

Section of the clavicular process showed spongy bone tissue, consisting of wide lacunae filled with bone marrow and covered by a thin layer of bone tissue; this was covered by a fairly thick layer of fibrous cartilage (Fig. 6). Section of the coracoid exostosis (Fig. 7) showed the same arrangement as in the former section, except that the layer of compact tissue was thicker and had typical Haversian systems. The covering cartilage presented fibrillation. A section, cut through the entire thickness of the articular disc, revealed a fibrocartilaginous arrangement (Fig. 8).

The second case was a chance discovery in a patient suffering from thoracic contusion. he patient had no complaints that could be attributed to this articulation. Figure 9 shows the abnormal articulation, not so fully developed as in the first case.

COMMENT

Frequency of the Anomaly

Most authors consider the coracoclavicular joint a rare anomaly. Gruber reported one case with a true articular capsule among thirty-eight shoulders examined. Pondé and Silveira examined 2,300 roentgenograms and found only one coracoclavicular articulation. Schlyvitch examined both shoulders of sixty cadavera and found the condition only once. Alarcón saw one case in ten years. Frassetto and Testut observed three cases each. We examined 277 roentgenograms of shoulders (177 unilateral and 50 bilateral) and found two cases. The works of other authors refer to only one case each. All of these men are unanimous in affirming the rarity of the anomaly. This rarity is contested only by Poirier, who observed three cases in ten cadavera, a frequency of 30 per cent., and Nutter, who examined 1,000 roentgenograms of adult shoulders and reported anomalous joints in twelve cases, or 1.2 per cent.

An attempt has been made to explain the difference between Poirier's and Nutter's

* By Godofredo Elejalde, M.D., of the Department of Pathology.

FIG. 9

Another patient with the same anomaly as that shown in Fig. 1, but which has recently developed without symptoms.

findings and those of the others. Miessen attributes little value to Poirier's cases, because Poirier does not state clearly whether or not he found a true joint, with a cartilaginous lining and an articular capsule.

Nutter's statistics of twelve cases in 1,000 do not agree with those of Pondé and Silveira, who in 2,300 roentgenograms found the anomalous joint only once. It is possible that this discrepancy is caused by the great variety of development and shape of the articular elements, which caused confusion among the authors as to the interpretation of the coracoclavicular joint.

Schlyvitch examined sixty cadavera and did not observe any surface of osseous contact at the site of the trapezoid and conoid ligaments in forty-four cases; in eight cases there were contacting surfaces, but they were covered by fiborus tissue; in only six cases did he find a more conspicuous process of the clavicle, lined by cartilage, and a corresponding coracoid surface, also lined by cartilage. Schlyvitch did not consider even these last six cases as true joints, because there was no articular fissure surrounded by a capsule. In only one case did he find a true diarthrosis with all its constituent elements. Schlyvitch thinks that roentgenograms are open to criticism, and he states that the true articulation can be shown only by dissection. It is possible that in the cases he dismissed—with conspicuous bony processes lined by fibrous or cartilaginous tissue, and an articular fissure but no articular capsule—the condition would be taken for true diarthrosis by roentgenologists, since these elements cannot be shown by roentgenograms.

The authors, such as Frassetto, Nutter, and Gradoyevitch, who reported cases with roentgenographic evidence, say that the presence of a clavicular bony process with a facet adapted to the adjacent coracoid process, like the articular surfaces of other true articulations, and with a clear articular fissure, leaves no doubt as to the existence of other elements that could not be shown by the roentgenograms.

These discussions are of no importance, because the point is not to recognize the type of joint, but to demonstrate the existence of an articulation, be it a *diarthrosis*, a symphysis, or another type of joint.

Clinical Importance

The articulation may exist without disturbance to the patient, as one sees by the accidental discovery of the coracoclavicular articulation in roentgenograms. The authors who refer to these as harmless articulations could not have followed the patients to see whether or not the anomaly caused any symptoms later, especially at the age at which the joints suffer degeneration, for the anomalous joint must be subject to the same pathological changes as every articulation.

According to Frassetto, this articulation is a predisposing factor in fractures of the surgical neck of the humerus through a direct or indirect blow, as this joint makes it almost impossible for the two bones of the shoulder girdle to separate, which is possible with the normal ligaments to a relatively large extent. The head of the humerus comes against the glenoid cavity, which is practically a rigid wall and, therefore, not able to soften the blows transmitted through the humerus; this would strain the resistance of the bone to its utmost, thus causing a greater probability for fractures. Frassetto quotes the case of a negro

woman with a bilateral coracoclavicular articulation, who fractured the surgical necks of both humeri in two falls.

Possati presents the case of a workman, sixty-three years of age, who complained of pain in his shoulder and had the movements of this joint restricted. The roentgenograms showed many osteophytic formations in the acromioclavicular and coracoclavicular joints and in the surrounding area. Possati considered these osteophytic formations to be a sign of osteo-arthritis in these joints, due to the continual movements to which the joints were subjected in consequence of the man's work as a stoker, and to the greater rigidity imposed on the region by the presence of the anomalous joint. This interpretation is confirmed by a roentgenogram of the other shoulder, which was perfectly normal.

Del Valle and Giordano observed a white woman, aged thirty-five, who had complained of pain in the left shoulder for one year, radiating to the mammary region, neck, and left arm. The pain was slight at the beginning and not influenced by analgesics, but gradually became worse with movement and was acute in the coracoid region, from which it radiated to the neck and axillary cavity. Occasionally she had an itching sensation in the last four fingers, followed by transient paralysis of the hand. The patient was submitted to different forms of treatment, without relief. At resection, a complete articulation was found. The complete success of the operation was confirmed a year later. The authors concluded that, as in the cervical-rib syndrome, there was sympathetic or plexal pain, due to compression of microscopic nerves, relieved by removal of the anomalous joint. This hypothesis was proved true by the production of pain by compression of the coracoid tip and by analgesia after local anaesthesia.

In our first case, no other cause of pain was found and only the anomalous joint could be held responsible. It is possible that this joint hinders the free motion of the shoulder, especially when the patient's work involves heavy labor, as in our case. The roentgenogram does not show articular impairment, but, as the patient is thirty-seven years old, it is probable that he would be subject to the future development of osteo-arthritis of the shoulder, as mentioned by Possati.

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DISCUSSION

INTERNAL FIXATION FOR LUMBOSACRAL FUSION

(*Continued from page 565*)

Dr. W. H. von Lackum conceived the same idea about one year later, and it has been employed by him and by other members of the staff of the New York Orthopaedic Hospital since then. More than two hundred fusions with the use of screws have been done.

The application of this method is limited, of course, to the lumbar spine. In fusion of the fifth lumbar vertebra to the sacrum, the results have been excellent. The comfort of the patient after operation and the avoidance of the necessity for external support alone have justified it. It has been possible to get the patients out of bed at the end of two weeks, and the subsequent convalescence has been greatly speeded.

When the fourth lumbar vertebra or any additional vertebrae were added to the fusion, the results were much less favorable. Instead of 92 per cent. success in obtaining bony fusion, the figure fell to 50 per cent. This was due in part to the notorious difficulty in bringing about a fusion of this joint as compared with the lumbosacral, which we encountered before the use of screws. It is true, also, that the introduction of screws into the laminae limits the amount of bone which can be stripped from them in doing the Hibbs operation. This necessitates the use of large quantities of additional bone, which we obtain from the patient's ilium or from the bone bank. In many cases an adequate amount of bone can be obtained from the sacrum when the fifth lumbar vertebra alone is fused, but not when the fourth is added. Failure to employ enough bone may account for some of our failures. We believe, also, that placing a wafer of bone in each joint space, after removal of the articular cartilage, helps in securing a fusion of the lateral articulations. The point to be emphasized is that one should not rely upon the screws alone, which afford only temporary support. In the light of our present experience, we have decided to apply a plaster jacket with double spica in all cases in which the fusion extends above the fifth lumbar vertebra, and are not sure that it might not be advisable to omit the screws from the joints above the level of the fifth vertebra. The screws have been found particularly useful, however, in cases of spondylolisthesis, in firmly securing the loose arch of the fifth lumbar vertebra to the sacrum, although this method does not bridge the defect in the laminae.

Deep infections occurred in three cases, but in only one was it necessary to remove the screws. In the others they did not become loose and fusion took place.

Dr. King deserves much credit for devising this simple and effective method which does so much to lessen the discomfort and shorten the convalescence after lumbosacral fusions.

BONE AND CARTILAGE DEBRIS IN THE SYNOVIAL MEMBRANE

Its Significance in the Early Diagnosis of Neuro-Arthropathy*

BY THOMAS HORWITZ, M.D., NEW YORK, N. Y.

*From the Laboratory Division**, Hospital for Joint Diseases, New York City*

This paper is devoted to the significance of the anatomical finding of bone and cartilage debris (detritus) in the synovial membrane as a possible indicator of the early evolutionary stage of neuropathy of a joint, notably in cases in which the clinical and roentgenographic findings, at least as far as the joints are concerned, are still those of an osteoarthritis. Attention will be focused specifically on five cases with involvement of the knee joint. In three of these, the diagnosis of neuro-arthropathy was first suggested by the results of histological examination of excised synovial membrane. In the other two, while there was some clinical evidence in favor of neuro-arthropathy, the diagnosis was substantiated by the pathological findings.

The anatomical findings in these five cases were controlled by a study of the synovial membrane from nineteen cases of fully evolved neuro-arthropathy of various joints (especially the knee), and thirty cases of synovitis and arthritis of the knee joint, clearly not having a neuropathic basis. These thirty cases included twelve with osteo-arthritis (degenerative arthritis), nine with rheumatoid arthritis (chronic inflammatory polyarthritis), and nine with one or another of various other articular lesions, such as intermittent hydrarthrosis or chronic synovitis with osteochondral bodies.

The significant pathological finding in the five cases of early tabetic arthropathy was the presence of cartilage and bone debris which had evidently been ground into the synovial membrane and subsynovial tissue, and occasionally into the articular cartilage. On the other hand, a survey of the pathological material removed from the knee joints of the thirty patients without neurological disease revealed similar findings in only two instances, and in both of these advanced degenerative arthritis was present. Although the blood Kahn and Kline tests were reported as positive in one of these two, there was no evidence of neurosyphilis to account for the articular changes in this case. This feature (bone and cartilage debris ground into the substance of the synovial membrane and underlying tissue), which is evident even in the earliest phases of evolution of neuro-arthropathies—in some cases, before clinical and roentgenographic evidence is demonstrable—is indigenous to all neuropathic joints, for it was manifest also in the pathological material from the nineteen cases in the more advanced stages of evolution (Figs. 1-C, 2-C, 3-C, and 5-A). However, its occurrence in an occasional case of advanced degenerative arthritis indicates that it is not absolutely specific to neuropathic joints (Fig. 5-B).

A review of the records of the five cases of early tabetic (Charcot) arthropathy with which this study is specifically concerned reveals the difficulties entailed in diagnosis at this stage, even when the available information—history, physical examination, laboratory data, and roentgenograms—has been critically evaluated; and it emphasizes the significance of the pathological findings in each instance.

Case 1. A fifty-year-old man entered the Hospital for Joint Diseases because of a painful swelling of the left knee, of ten months' duration. There was no history of injury. He had had a primary syphilitic lesion a number of years before. The knee demonstrated marked effusion, coarse crepitation, and limited motion. The blood Kahn and Kline tests were reported as negative. The Romberg sign was negative, the ankle and knee jerks were absent; and sensation to touch in the lower extremities was diminished. Roentgenograms

* Work done under a Frederick Brown Research Fellowship in Orthopaedic Surgery.
** Henry L. Jaffe, M.D., Director.

of the knee joint showed some marginal bony lipping and an intra-articular effusion with synovial thickening (Figs. 1-A and 1-B). A synovectomy and lateral meniscectomy were performed.

FIG. 1-A FIG. 1-B

Case 1. Anteroposterior and lateral roentgenograms of the left knee at the time of first admission show slight marginal bony lipping and indications of an intra-articular effusion with synovial thickening. There are no features suggestive of a neuro-arthropathy.

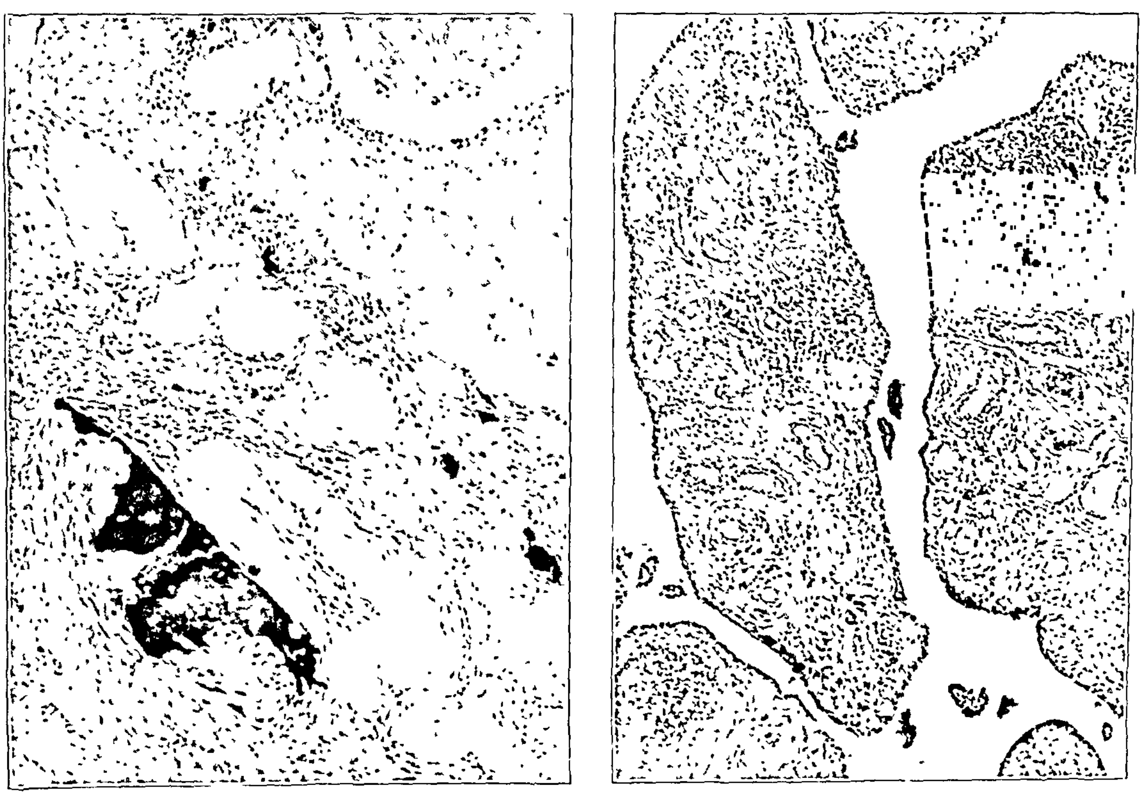

FIG. 1-C FIG. 1-D

Fig. 1-C: Microscopic section (×50) of synovial tissue, removed at first operation, shows the presence of bits of cartilage and bone detritus ground into the substance of the synovial membrane. Several islands of cartilage and bone metaplasia are present.

Fig. 1-D: Microscopic section (×30) of an area of villously hypertrophied synovial membrane, demonstrating dilatation of numerous vascular channels and considerable round-cell infiltration; this appears in areas as focal collections, some of which are perivascular. This feature has been reported by Allison and Ghormley as specific to rheumatoid arthritis.

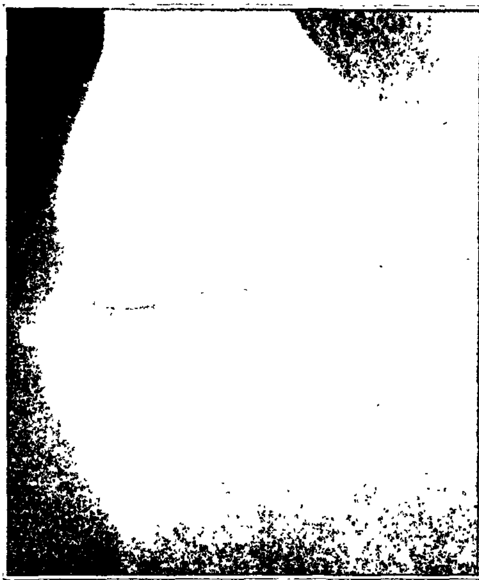

FIG. 2-A

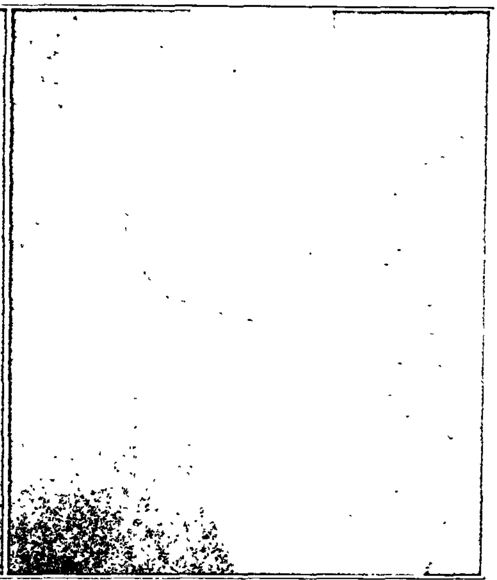

FIG. 2-B

Case 2. Anteroposterior and lateral roentgenograms of right knee show marginal bony proliferation, narrowing of the joint space, and indications of intra-articular effusion with synovial thickening. There is a suggestion of sclerosis of the lateral femoral condyle and of very slight lateral displacement of the tibia, but these findings have significance only in retrospect, for the neurological examination and blood serological tests were negative at this time.

Fig. 2-C: Microscopic section of synovial membrane (×30) shows numerous spicules of bone and calcified cartilage debris, ground into the subsynovial tissue. Several islands of cartilage and bone metaplasia are also present.

FIG. 2-C

The pathologist reported the presence, in some of the excised material, of bits of cartilage and bone detritus within the substance of the synovial membrane, and suggested the possibility of a Charcot arthropathy (Fig. 1-C).

The patient was readmitted two years later with some pain, marked swelling, and instability of the left knee, and roentgenographic evidence of progressive joint disintegration. Tissue removed at a second operation showed the progressive destruction of all the articular components which is characteristic of a well-advanced neuro-arthropathy.

Comment: Despite a history of syphilis and equivocal neurological findings, the diagnosis of a neuropathic joint, suggested by the pathologist, did not at first appear to be sustained; but it was upheld by the clinical, roentgenographic, and pathological evidence two years later.

CASE 2. A man, fifty-one years old, slipped and injured his right knee, which became swollen and painful. Two neurological examinations during the ensuing months of his continued disability revealed nothing remarkable. The roentgenograms of the knee joint (Figs. 2-A and 2-B) were interpreted

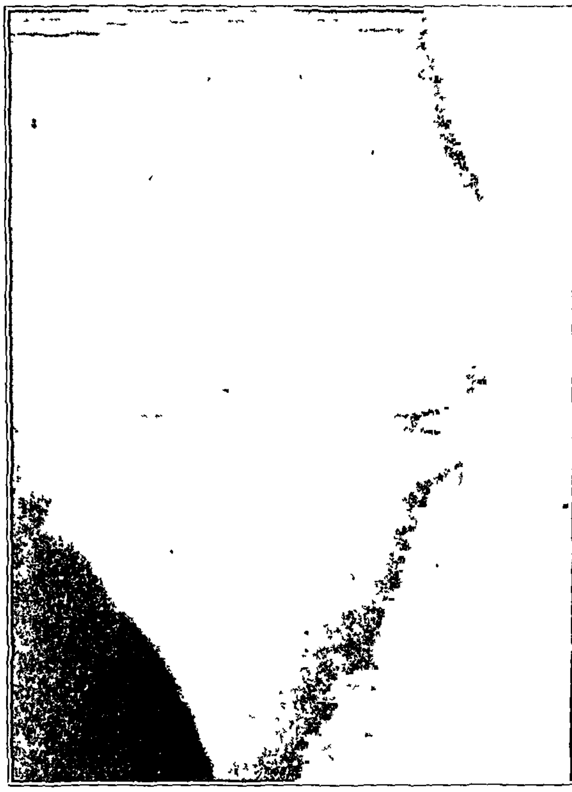

FIG. 3-A

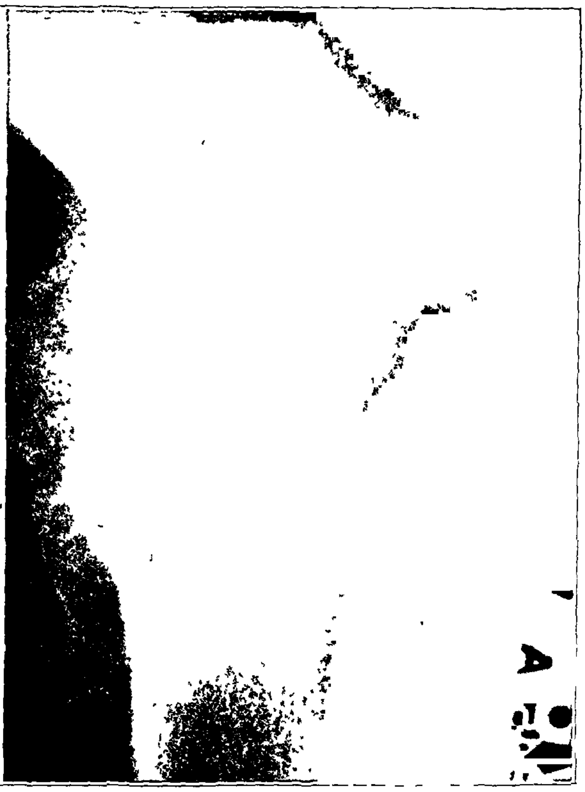

FIG. 3-B

Case 3. Anteroposterior and lateral roentgenograms of right knee, taken just before synovectomy. *There is marginal lipping, intra-articular effusion, and synovial thickening.* This was reported as an instance of osteo-arthritis. The sclerosis of the medial femoral condyle and the slight periostitis of the distal portion of the shaft of the femur are significant only in retrospect, in view of the negative blood and spinal-fluid serological tests and the normal neurological findings at this time. (The illustration for Fig. 3-B has been reversed.)

FIG. 3-C

Fig. 3-C: Section (×30) demonstrating small fragments of calcified cartilage and bone within the synovial tissue, round-cell infiltration, and vascular dilatation.

as demonstrating early osteo-arthritis. At the end of nine months, the appearance of slight lateral instability of the right knee joint and of altered pupillary reflexes suggested to one of the examining physicians the possibility of a neuropathic joint. The patient entered the Hospital one month later for surgical fusion (which has failed to take place). At that time the blood Kahn and Kline tests were reported as negative, and the spinal-fluid Kahn test as weakly positive (2 plus). The roentgenographic features of a neuro-arthropathy—synovial thickening, eburnation of the bone ends, free bone fragments in the joint cavity, and periostitis at the distal end of the femur—were evident.

Study of the synovial membrane removed at operation showed, in many areas, bits of bone and cartilage ground into it. There were also some fragments, representing nidi of bone formation (metaplasia) (Fig. 2-C).

Comment: A neuropathy of the joint, in its incipient stage, may manifest itself long before any abnormal neurological findings become evident. In this case the neurological

and roentgenographic evidence "matured" under the observation of several competent examiners, and the possibility of a neuro-arthropathy was considered only nine months after the onset of joint symptoms. This evidence was sustained by the results of histological study of the synovial membrane.

CASE 3. A man, fifty-two years old, injured his right knee in a fall, six weeks before he came to the Hospital. The knee was swollen and moderately painful, and there was lateral instability of the fully extended knee. Serological tests of the blood and spinal fluid were reported as negative. The neurological examination yielded normal findings. A synovectomy and excision of the medial and lateral menisci were performed: a mild postoperative infection ensued.

The pathologist at the Hospital, observing bone and cartilage detritus ground into the synovial membrane, suggested the possibility of a Charcot arthropathy (Fig. 3-C).

At the present time, four and one-half years later, the patient admits that he has a history of syphilitic infection; certain abnormal neurological signs—a positive Romberg sign and Argyll Robertson pupils—are present. His reflexes and sensation are still normal. The original roentgenograms have demonstrated the features of an early neuropathy of the joint only in retrospect, and were not so reported originally. They show some effusion, very early bone condensation, and slight periostitis (Figs. 3-A and 3-B). Solid bony fusion has occurred in the knee which was operated upon.

Comment: Although the early clinical and roentgenographic evidence in this case was not interpreted as indicating the presence of a neuropathic joint, the pathologist suggested this diagnosis on the basis of the histological study of the synovial tissue. This was upheld four and one-half years later when the patient, admitting a past syphilitic infection, demonstrated the features of early tabes dorsalis.

CASE 4. A woman, sixty-three years old, was admitted to the Hospital with a diagnosis of hypertrophic arthritis of the right knee joint, for the purpose of a synovectomy. Pain and recurrent swelling had followed an injury, eighteen months previously. During the interim, she had received physiotherapy and non-specific protein injections and had had repeated aspirations of the knee-joint fluid. The earlier roentgenograms were reported as showing advanced osteo-arthritis. The blood Wassermann and Kahn tests were reported as negative; the spinal fluid was not examined. The results of the neurological examination were considered to be negative (intern's note). On admission to the Hospital the knee was quite sensitive: motion was restricted and painful; and there was marked crepitus and some lateral instability of the fully extended knee. The roentgenograms then showed changes—moderate effusion, osteosclerosis, free bone fragments, narrowed joint space, and slight anterolateral luxation of the tibia—which suggested the possibility of a Charcot arthropathy. A fusion operation was performed, but the patient died of cardiac failure, one month later.

Microscopic sections of the tissue which had been excised in the course of the arthrodesis showed pronounced osteo-arthritic changes in the bone ends. In some areas, however, the synovial membrane revealed bits of bone detritus embedded in the membrane. The capsule was thickened and, in places, demonstrated islands of fibrocartilaginous tissue (metaplasia).

Comment: The roentgenograms assumed features suggestive of a neuropathic joint only after ten months of observation, during which period the diagnosis was not suspected. The impression of neuro-arthropathy was sustained by the pathological findings. A review of the records reveals that no significance was attached to the fact that the patient had admitted having been treated for syphilis and that she had had eight miscarriages.

CASE 5. A man, fifty-seven years old, sustained an injury to the right knee in 1940. He was a known syphilitic, having received specific antisyphilitic therapy for the preceding four years. Four months after his injury a synovectomy was performed, with removal of a partially detached medial meniscus. Three years later, because of continued pain and disability, a second arthrotomy was performed, at which time the lateral meniscus was removed. In 1946 he was readmitted because of continued pain and disability in the right knee, and specifically for surgical fusion. There was limitation of motion, but no preternatural mobility of the affected joint. Kahn and Kline tests of the blood and spinal fluid were reported to be strongly positive. The neurological picture at that time was that of an "incomplete tabes dorsalis" (Argyll Robertson pupils, absent knee and ankle jerks). The roentgenograms were reported as showing advanced osteo-arthritis with free osteochondral bodies in both knees (Figs. 4-C and 4-D).

The histological study of tissue excised at the time of arthrodesis revealed tiny, scattered bony fragments ground into the synovial membrane, and the pathologist suggested that these might be the early expression of a Charcot arthropathy.

Comment: In this patient, with neurosyphilis and painful disability of both knee joints, more marked on one side, after an injury, the clinical and roentgenographic features were those of osteo-arthritis (Figs. 4-A, 4-B, 4-C, and 4-D). The *diagnosis of a Charcot* arthropathy was suggested from the pathological findings, and the postoperative care of this patient was conducted with this in mind. Failure of fusion and progressive osteo-

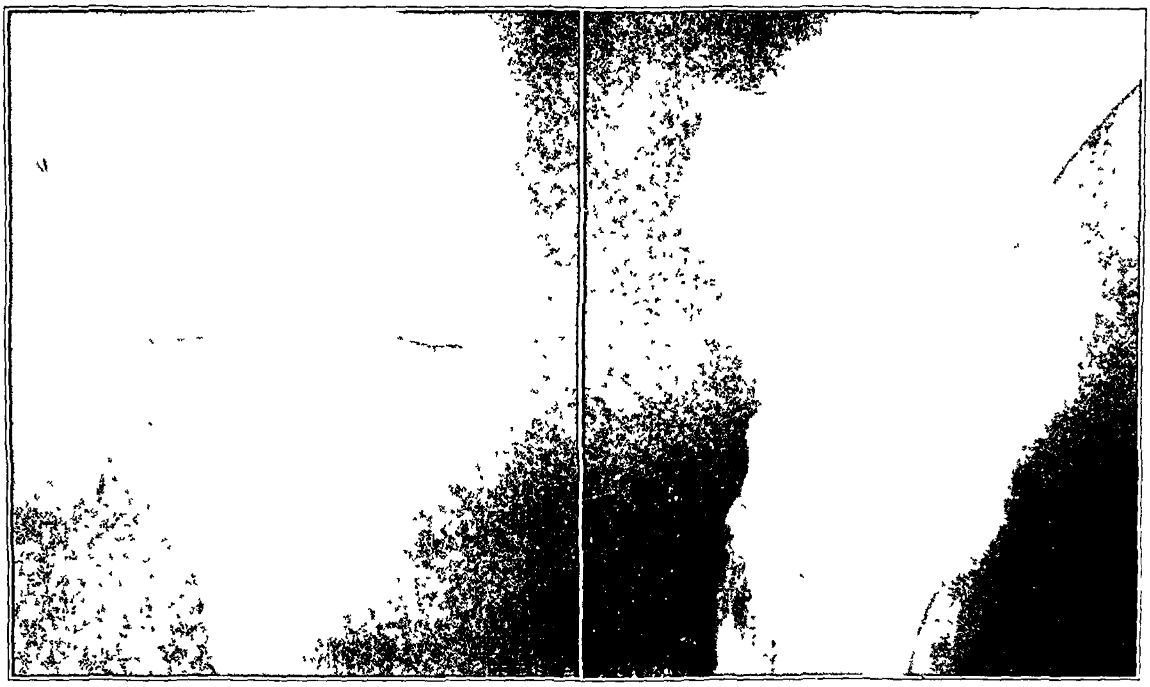

Fig. 4-A Fig. 4-B

Case 5. Anteroposterior and lateral roentgenograms of right knee, taken in 1941, show marginal lipping, narrowing of the joint space, several osteochondral bodies (the one directly posterior to the femoral condyle is probably a fabella), and synovial thickening. There is nothing to suggest the presence of a neuro-arthropathy.

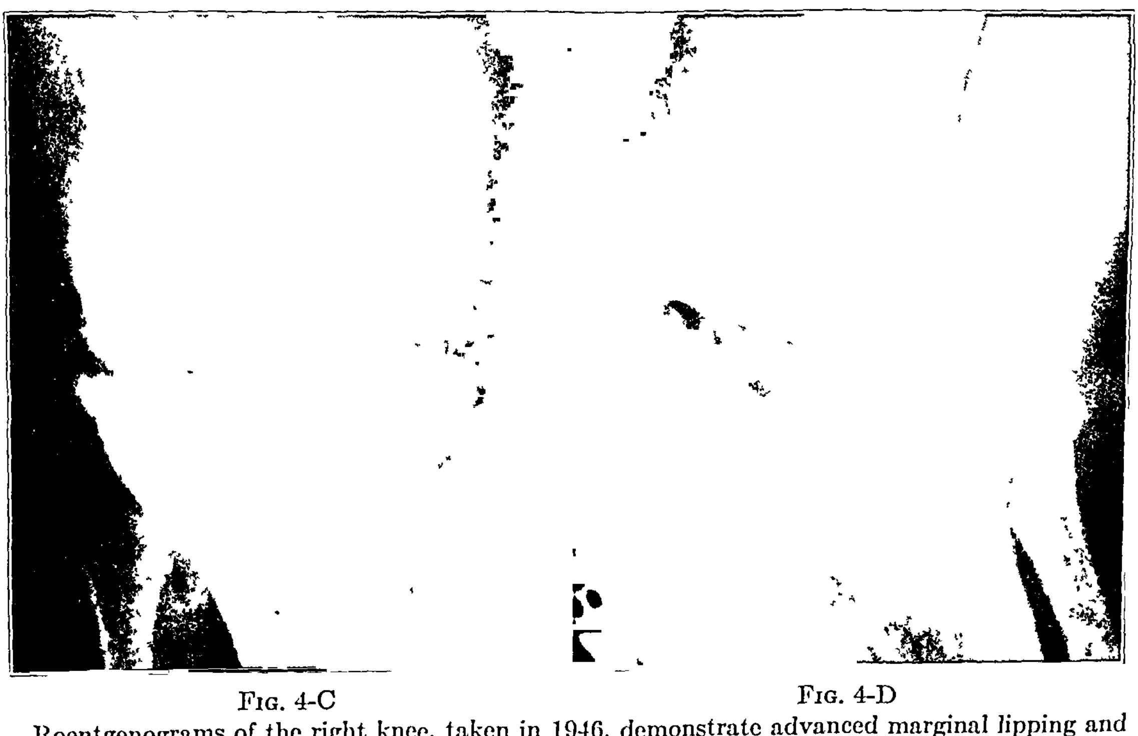

Fig. 4-C Fig. 4-D

Roentgenograms of the right knee, taken in 1946, demonstrate advanced marginal lipping and joint narrowing, and hypertrophy of the free bodies. The appearance of osteosclerosis of the distal end of the femur and of the proximal end of the tibia, slight lateral displacement of the tibia, and some compression of the outer lip of the lateral tibial condyle may be interpreted as evidence of early neuropathy of the joint, although such changes are readily demonstrated in moderately advanced stages of osteo-arthritis.

FIG. 5-A

FIG. 5-B

Fig. 5-A: Section of synovial membrane removed from the right knee of a man, fifty-one years old, at the time of surgical fusion. Patient presented positive blood Kahn and Kline tests, and clinical and roentgenographic evidence of a well-advanced tabetic arthropathy. Since then, evidence has developed of neuro-arthropathy in one wrist joint and in the opposite knee joint.

Section (×30) shows the presence of bits of cartilage and bone debris on the surface of and within the synovial membrane. Several islands of cartilage and bone metaplasia are also present. These changes were widespread throughout all the histological sections. On the other hand, in the *early* stages of a neuro-arthropathy, a large number of sections may have to be studied in order to disclose this finding (see Figs. 1-C, 2-C, and 3-C).

Fig. 5-B: Section of synovial membrane from a painfully swollen right knee in a male, forty-nine years old, at the time of synovectomy and meniscectomy. Patient presented normal stability of the knee joint and normal neurological and laboratory findings; and the roentgenograms of the knee joint disclosed a moderately advanced osteo-arthritis with several osteochondral bodies.

Microscopic section (×30) shows cartilage and bone debris ground into the sub-synovial tissue,—changes which suggested the possibility of an early neuro-arthropathy. This suspicion was not sustained in a clinical and roentgenographic follow-up study, two years after operation.

sclerosis of the bone ends appear in keeping with a diagnosis of neuro-arthropathy rather than with that of degenerative arthritis, in a patient with neurosyphilis.

DISCUSSION

Diagnosis

These cases illustrate the difficulties in the early clinical and roentgenographic diagnosis of Charcot's arthropathy. Even when the available findings are evaluated critically, the diagnosis may remain in doubt or be overlooked. The neurological examination has been considered the most constantly reliable of all this evidence in the establishment of the diagnosis of neuro-arthropathy[15, 18, 19].

A history of syphilitic infection or of specific antisyphilitic therapy was obtained in only 70 per cent. of the twenty-four cases in this study. Pain was often the predominant symptom, although, in the later stages of evolution of the neuro-arthropathy, it was not so intense as one would expect in view of the extent of joint destruction. Serological tests for syphilis were helpful in less than 50 per cent. of the cases. Those roentgenographic features which are characteristic of neuro-arthropathies may not be evident in the earlier stages of evolution. In the five cases recorded here the early roentgenograms were not

helpful, although in two of these the later roentgenograms assumed more characteristic features and assisted in clarifying the diagnosis.

Pathological Findings

The descriptions of proliferative and degenerative, or of benign and malignant, types of neuro-arthropathy which appear in the literature are superfluous, since these processes appear simultaneously or progressively in the same joint and represent different stages of repair and destruction. Such progressive changes were demonstrated in the material from several patients in this study, where more than one arthrotomy had been performed prior to clarification of the true nature of the joint disability.

The detailed pathological descriptions appearing in the literature[2, 8, 9, 10, 13, 14, 16] have focused attention on the lesion in the more advanced stages of evolution,—that is, degeneration of articular cartilage, reactive phenomena in the revivified subchondral region, severe disruption at the cartilage-bone juncture, and the stimulus to ossification at the margins of the joint and in the peripheral soft tissues. The synovial membrane may be thickened and villously hypertrophied and may even demonstrate considerable infiltration of round cells, collections of which closely resemble the focal collections reported as specific to the proliferative (rheumatoid) type of arthritis (Fig. 1-D).

The most striking pathological feature, manifest even in the earliest phases of evolution of a neuro-arthropathy, consists of the presence of collections of bone debris and bits of cartilage, ground into the synovial membrane and subsynovial tissue (Figs. 1-C, 2-C and 3-C). In the earlier cases, a large number of representative histological sections from the synovial and capsular tissues may have to be surveyed in order to disclose this feature; it was demonstrated in every case of neuro-arthropathy in this series. The amount of detritus appeared proportionate to the degree of disruption of the remaining components of the affected joint, and to the severity or stage of evolution of the neuro-arthropathy and of its underlying neurological disturbance (Fig. 5-A). Its presence suggests a pathogenesis on the basis of debris formed through the erosion of articular cartilage and subchondral bone, which has been ground into the articular soft tissues by continued weight-bearing on a joint less sensitive than it would normally be [6, 7].

This partially necrotic bone and cartilage detritus should not be confused with expressions of fibrocartilaginous and osseous metaplasia which may also be evident in the synovial and periarticular soft tissues in these cases, but which is likewise found frequently in cases of degenerative arthritis and particularly in cases of chronic synovitis, characterized by multiple osteochondral-body formations. That syphilis itself is not a factor is indicated by the absence of bone and cartilage debris in the synovial membrane from a case of syphilitic gonitis and from two cases of advanced degenerative arthritis with strongly positive blood serological reactions. This feature is not to be confused with the observation of occasional osseous fragments, lying isolated within a collection of infected granulation tissue in cases of tuberculous or pyogenic arthritis, and obviously the result of direct invasion and destruction of bony trabeculae. It should likewise not be confused with the occasional bone fragment, found free in the soft tissues in some cases of osteochondral fracture. However, necrotic bone debris may be found in cases of extensive aseptic necrosis of the bone (namely, of the femoral head) within the capsular synovial membrane, at or close to the capsulo-articular juncture. However, in these cases the total clinical and anatomical picture presents no problems of interpretation.

Treatment

Since patients presenting the earlier phases of a neuro-arthropathy may be subjected to surgery under the mistaken impression of the presence of a "non-descript degenerative arthritis", "chronic synovitis", or "internal joint derangement", the pathologist may be the first to suggest the possibility of a neuro-arthropathy or to substantiate the clinical

impression that such a condition is present. This is illustrated in the five cases reported here. On the basis of such a pathological analysis, the clinical survey should be intensified or the patient should be followed carefully for progressive clinical and roentgenographic developments; or, if the pathologist's impression appears sustained by other evidence, the affected joint should be protected adequately or subjected to definitive surgery. In addition, this pathological finding of imbedded bone and cartilage debris should place the surgeon on guard as to after-care and prognosis.

The results of surgical therapy directed at stabilizing neuropathic joints have been uniformly poor. This is brought out incidentally in the present study. Fusion operations on the knee joint failed in ten of twelve instances, while all other reconstructive procedures, including synovectomy and débridement, were entirely fruitless; all fusion operations on the hip joint failed (three cases); amputation was necessary in the two instances of Charcot's foot with malum perforans pedis and complicating osteomyelitis and in one case of Charcot's disease of the ankle joint.

Although the knee joint has been considered the most adaptable articulation for stabilization by arthrodesis, successful fusions of this joint, when it has been the site of a neuro-arthropathy, have been sufficiently infrequent to warrant their report[3,4,5,11,12,17]. It is possible that many of the failures to secure bony union, despite the use of acceptable techniques, which have included joint excision, massive bone grafts, and rigid internal fixation, have been related directly to the fact that, in moderately advanced and especially in well-advanced neuro-arthropathies, the osseous components of the articulation are involved for a considerable distance from the articular surfaces, and thus may exceed the bounds of usual joint resection. For this reason, perhaps better surgical results may be anticipated if the diagnosis of neuropathic joints can be made in their earliest evolutionary stage.

CONCLUSIONS

The observation of bone and cartilage debris ground into the synovial membrane appears to have diagnostic value in the early evolutionary stages of neuro-arthropathy in cases wherein the clinical and roentgenographic features are equivocal, being still those of an osteo-arthritis. This feature served as the basis for the diagnosis by the pathologist of neuro-arthropathy in its earlier stage of evolution in five patients, three of whom presented no other evidence of such a lesion; in the other two cases, the clinical and roentgenographic evidence was equivocal. It has been a constant finding in the pathological material from all patients with neuropathic joints. Furthermore, the amount of bone and cartilage detritus appeared proportionate to the degree of disruption of the remaining components of the affected joint, and to the stage of evolution of the neuro-arthropathy and of its underlying neurological disease. However, since, in a control group of thirty cases with operable lesions of the knee joint, it was also found in the material from two cases of advanced degenerative arthritis of the knee joint without a neurogenic basis, one must conclude that the observation of imbedded debris, while highly suggestive, is not altogether specific to the neuro-arthropathies.

The pathogenesis appears to be based on the formation of debris through the erosion of articular cartilage and subchondral bone, which has become ground into the articular soft tissues by continued weight-bearing on a joint less sensitive than a normal joint.

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DISCUSSION

Muscular Torticollis

(Continued from page 569)

I am willing to learn. As far as I can remember, where torticollis has been discovered before the child was four weeks of age, and where muscle stretching has been properly carried out, there has been no case that did not result in a complete cure. I feel it is our duty to keep the obstetricians and pediatricians constantly on the alert to discover this condition, so that it may have immediate attention.

Dr. J. Albert Key, St. Louis, Missouri: I would like to protest against operating upon these children until they are at least two years of age, and until one is sure they are going to need surgery. I think nearly all of these tumors disappear if left alone. I have not applied a cast after operation for torticollis for over fifteen years, and I have been careful to try to completely correct the deformity at the operation. This is done by lengthening the muscle rather than by resecting. The clavicular portion is separated from the sternal portion, which is high in the neck. The clavicular portion is then removed from the clavicle, and the two are sutured end-to-end as in a "Z" lengthening of a tendon.

Dr. J. S. Speed, Memphis, Tennessee: I cannot let this paper go by without a short discussion to corroborate the findings Dr. Chandler has brought before you. We have very carefully watched our patients, and have operated upon six who were two months old and two who were three months old. The microscopic and pathological findings were identical with those Dr. Chandler has described. I am not at all satisfied with the explanation about the etiology.

As to the appropriate time for operation, I believe our enthusiasm has stimulated operation in two or three weeks. On the other hand, I think six weeks is preferable; by then you will know whether the lesion is going to be absorbed spontaneously or not. I believe this is the optimum time for operation.

I think Dr. Chandler's article is a very definite contribution to the study.

Dr. Fremont A. Chandler (closing): There must be a large number of these cases. If in my limited experience I can see 225, the number of cases seen by the men in this room should run into many thousands.

The venous supply is abundant, and during the operation there is bleeding from all directions. The arterial supply is more zonal in character. The anastomosis is abundant, even in some portions of the tumor itself.

BONE AND JOINT CHANGES IN HEMOPHILIA

With Report of Cases of So-called Hemophilic Pseudotumor*

BY RALPH K. GHORMLEY, M.D., ROCHESTER, MINNESOTA

Section on Orthopaedic Surgery, Mayo Clinic

AND REED S. CLEGG, M.D., ROCHESTER, MINNESOTA

Fellow in Orthopaedic Surgery, Mayo Foundation

The changes seen in the joints of persons affected by hemophilia are familiar to members of the medical profession. In addition, changes may be seen in the shafts of the long bones in some cases of hemophilia. Such changes are seen much less frequently than are the joint changes and, in the authors' experience, are more severe and result in disaster in most instances. Various authors have stated their opinions regarding the frequency of joint changes in hemophilia. Lyon-Smith reported that, in 70 per cent. of his hemophilic patients, hemarthrosis developed before the age of two years. In more than 78 per cent. of the patients followed by Thomas, joint symptoms developed, usually during childhood; and in some of the remainder the joints were affected later. In a series of seventy-six patients with hemophilia examined at the Mayo Clinic, forty-four or 58 per cent. showed definite evidence of pathological changes in the bones or joints. (There were in the files 150 cases in which a diagnosis of hemophilia had been made in the years 1920 to 1939, inclusive. Each patient in this series was graded as 1, 2, or 3 on the basis of (a) a history of hemophilia among relatives and (b) clinical and laboratory evidence of hemophilia. Only those patients with ratings of 2 or 3—that is, those with definite evidence of hemophilia—are included in this series.)

All of the forty-four patients in this series in whom pathological changes developed in the bones and joints were males. Their average age was 17.3 years. When first seen here, thirteen patients were younger than ten years; twelve ranged from ten through nineteen years; ten, from twenty through twenty-nine years; five, from thirty through thirty-nine years; and four, from forty through forty-nine years. The average age is fairly high, because the majority of these patients presented themselves during the chronic stages for treatment of complications. The known age at the onset of hemarthrosis ranged between four months and thirty-five years, the average being about seven and one-half years.

Table I shows the joints first involved in thirty-nine of the forty-four patients, and Table II shows the comparative frequency of involvement of the individual joints. It is obvious that weight-bearing joints were involved more frequently than non-weight-bearing joints, and the knee was involved about twice as often as any other joint. Of the forty-four patients with hemarthrosis, ten or 23 per cent. had single joints involved, while thirty-four or 77 per cent. had multiple joints involved.

Six patients with unusual bone changes were included, five of whom were known to have hemophilia; one had some type of blood dyscrasia or hemorrhagic diathesis which was never positively diagnosed. The extensive changes found in the joints are familiar to those interested in hemophilia, but our experience has led us to believe that the bone changes, such as those seen in these cases, are much less frequent and are less familiar to all interested in the disease than are the changes in the joints. Previous reports in the literature of cases with extensive bone changes, similar to those to be reported here, are as follows:

Starker is credited by Echternacht with being the first to describe such a lesion.

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 27, 1947.

TABLE I

PRIMARY JOINT INVOLVEMENT IN FORTY-FOUR CASES OF HEMOPHILIA WITH BONE AND JOINT CHANGES

Location		No. of Cases
Knee		23
Right	15	
Left	8	
Ankle		6
Elbow		4
Hip		3
Wrist		1
Patella		1
Phalanx		1
Not given		5
Total		44

In Starker's case of hemophilia, a large tumor of the right thigh had developed; this was probed and a considerable amount of blood was evacuated. The patient died ten days later, and Echternacht quotes from the postmortem notes: "There was erosion of the cortex and spongiosa beneath the hematoma at the lower end of the femur. Calcified connective-tissue strands extended from the cortex to the elevated periosteum on the anterior surface. Histologically no evidence of neoplasm was seen."

Reinecke and Wohlwill reported extensive subperiosteal hemorrhages in a man, aged twenty-seven years, with hemorrhage into the knee. The disease ran a variable course, but the patient died after three months in the hospital. A complete report of the postmortem findings was given. Roentgenograms showed erosion of the bone, "as seen in cases of aneurysm against vertebrae or sternum". The diagnosis at necropsy, as translated, was: "Hemarthrosis of the right knee. Bone erosion on the medial condyle of the femur and tibia, new and old subperiosteal bleeding, anaemia, acute lung emphysema. Streptococcaemia." An excerpt from the extensive description of the microscopic findings is as follows: "Surprising is the picture of the surface of the cortex. Here we see nowhere a continuous, compact bony layer. At the upper and lower edges of the hematoma, as well as where the periosteum is still attached and where it is lifted up by hematoma, we find numerous bone spicules, at times surrounded by osteoblasts, attached to the bone, and between them cellular bone marrow, here and there still containing some pigment cells. The border between this new-bone formation and the old cortex is not a smooth surface, but the spongy spicules are attached irregularly to the cortex and also irregularly enter cellular marrow spaces into the cortex.

"In the region in which the hematoma lies directly on the bone one can see how the blood, or rather the granulation tissue formed from the blood, has perforated the surface of the bone and entered into it. A few bone fragments have been separated by this process entirely and become necrotic. Around these lost fragments, as well as the ones still connected with the cortex, one finds giant cells with lacuna formation by erosion." *

Firor and Woodhall presented a case of a white boy, sixteen years old, with pain and swelling of the right thumb of eighteen months' duration, which they believed "to represent the end stage of a traumatic hemarthrosis of hemophilic origin in a small articulation". Their case is similar to Case 4 of this series.

Becker reported two cases of so-called resorption tumors which he also called hemophilic pseudotumors. One of these lesions had afflicted a man, fifty-one years old, of a family known to have a tendency to hemorrhage. A few years before he had been kicked

* Translation by Dr. A. R. Pils.

TABLE II

FREQUENCY OF JOINT INVOLVEMENT IN FORTY-FOUR CASES OF HEMOPHILIA WITH BONE AND JOINT CHANGES

Location	No. of Cases
Knee	45*
Elbow	28
Ankle	26
Hand	13
Hip	8
Wrist	5
Patella	4
Phalanx	3
Sacral spine	1

* In some cases both knees were involved.

in the thigh by a horse. This had been followed by the development of a large hematoma. Within nine months a tumor appeared and enlarged slowly. Exploratory operation was performed. A tumor was found, involving the muscle and extending down to the femur. The patient died thirteen days after operation, of tetanus. A translation of the pathologist's report on the tissue was "proliferation of fibrous tissue containing blood pigment, next to foreign-body giant cells, and granuloma formation around foci of hemoglobin as well as lipoid-containing cells".* A second case involved a man of twenty-three years, known to have hemophilia, who had a gradual swelling of the thigh. Needle biopsy was followed by severe bleeding. The roentgenogram showed a well-defined radiopaque mass, distal to the lesser trochanter. The cortex appeared to be ruptured, as would occur in periosteal sarcoma. Biopsy of a node from the inguinal region revealed many pigment-containing cells, but nothing else.

Echternacht reported the case of a white boy, thirteen years old, who was a known hemophiliac with a history of repeated hemorrhages into various joints. He was finally admitted with a painful swelling of the anterior surface of the left tibia, just below the knee. This had followed a slight injury, three months previous to admission. Roentgenotherapy and transfusions failed to arrest the enlargement of the tumor, and an exploratory operation revealed an extensive hematoma. No neoplastic tissue was found. Finally a disarticulation through the knee was performed and death ensued. The specimen showed "large subperiosteal hematoma with massive necrosis of the underlying bone and necrosis and infection of the overlying skin".

Among the six patients in this series with unusual bone changes was one with involvement of the phalanges of the thumb, one with involvement of the olecranon, and four with involvement of the femur. In each case the involvement was monostotic. In all cases the most nearly adjacent joint was involved to some extent, and reasonable doubt may exist as to whether the bone changes were secondary to hemorrhages within the joint or whether they were due to primary hemorrhages within the bone or in the subperiosteal tissue adjacent to the bone.

REPORT OF CASES

CASE 1. A young man, nineteen years old, first registered at the Mayo Clinic on April 15, 1927. His chief complaint was intermittent pain and swelling with stiffness of the elbows of two and one-half years' duration. The mother, who accompanied the patient, stated that the patient's father's brother was a bleeder and also his father's brother's son. The patient had had frequent attacks of nosebleed, for relief of which epinephrine packs were required, up to two or three years before admission. Hemorrhages from small cuts lasted up to half an hour and were controlled only by pressure. Two years before admission the patient had had whooping

* Translation by Dr. A. R. Pils.

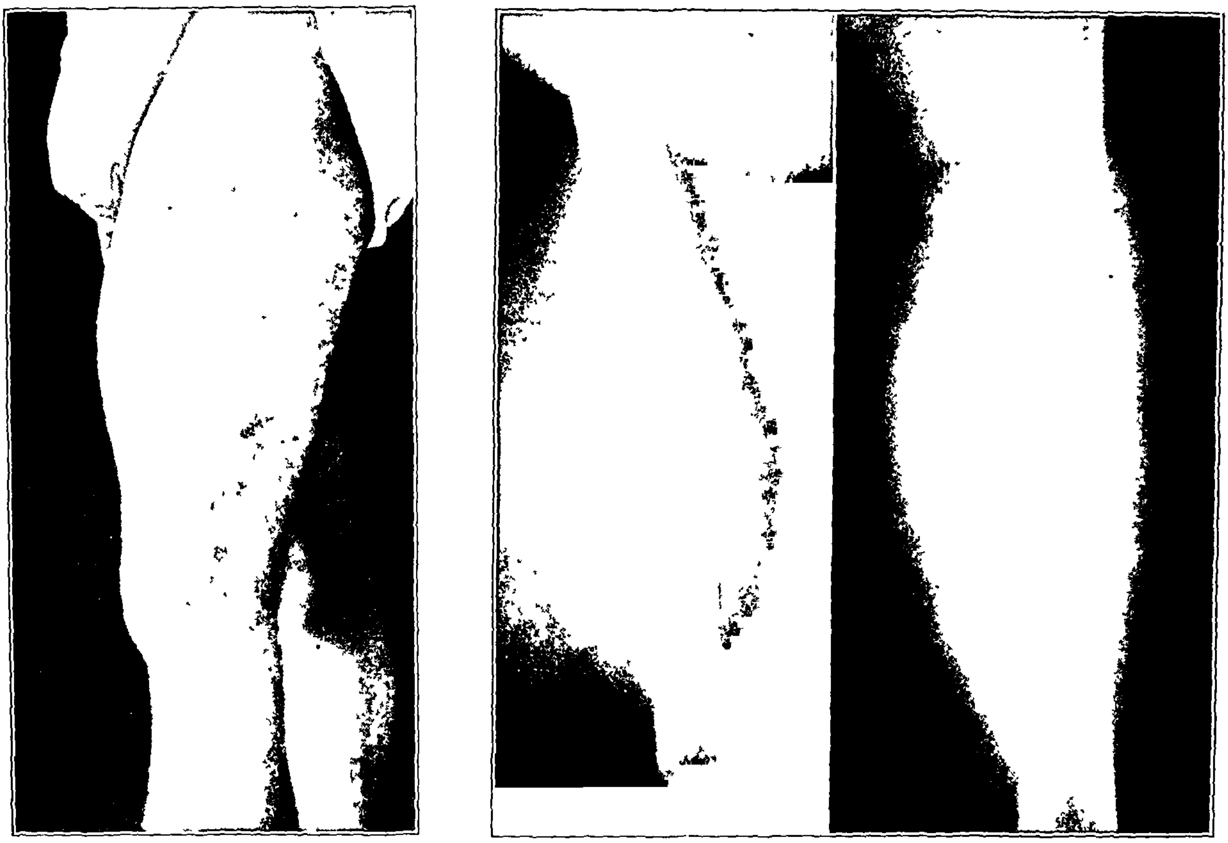

FIG. 1-A FIG. 1-B FIG. 1-C

Fig. 1-A: Case 1. Moderate swelling of the left thigh.

Figs. 1-B and 1-C: The femur in 1927, seven years before death. Lateral view (Fig. 1-B) shows enlargement of femur from subperiosteal calcified hematoma. Anteroposterior view (Fig. 1-C) shows erosion of cortex along medial surface.

cough, during the course of which swelling and pain in the thigh developed. The swelling was present at the time of his admission to the Clinic, but it was not painful. For about the same period of time the patient had had recurrent attacks of pain and swelling of the elbows, with limitation of motion. He had also had pain in the left groin, three years before admission, with a palpable mass which he thought was due to hemorrhage. Examination showed swelling of the thighs (Figs. 1-A, 1-B, and 1-C); movement of the elbows was limited to 160 to 130 degrees on the right and 170 to 140 degrees on the left. The following laboratory findings were noted: hemoglobin 66 per cent.; erythrocytes 4,270,000 and platelets 228,000 per cubic millimeter of blood. The coagulation time was ten minutes and the bleeding time twelve minutes. A Wassermann reaction was negative, and clot retraction was complete at the end of two hours. The patient was seen by a consultant in hematology, who made a diagnosis of hemophilia. No treatment was advised.

Several years later, in 1933, the patient wrote that he continued to have trouble with the thigh and the elbow joints. He stated that his thigh was thirty-two inches in circumference near the groin and twenty-eight inches above the knee.

On April 3, 1934, the patient's physician wrote that the patient had died a few days before and that permission had been obtained for a partial autopsy. He stated: "While our sections are not yet completed, I am positive that this enormous tumor was merely a subperiosteal hemorrhage. There was no arteriovenous aneurysm, nor anything that looked like sarcoma, grossly."

Later the protocol of the necropsy was forwarded to us, but unfortunately the roentgenograms had been destroyed and no copies had been made. The following is an excerpt from the protocol: "Examination reveals the body of a young male adult about twenty-five years of age, with moderate oedema of the lower portion of the abdomen and the left flank. The entire left leg and thigh are enormously swollen, the enlargement being most marked from the region of the hip to a short distance below the knee. Circumference at mid-thigh is thirty-two and one-half inches; just below the greater trochanter it is thirty-one inches; and at the knee it is twenty-eight inches.

"On the lateral aspect of the left knee is an ulcerated area of about three or four inches, in the center of which is a sinus tract, leading to the deeper tissues and having an external opening about one inch in diameter. The base of the ulcer is covered by gelatinous material. Several areas on the anterior and lateral aspects of the upper thigh are denuded of the superficial layers of skin, but ulceration has not occurred. The entire left leg is boggy and somewhat fluctuant. The leg is oedematous below the knee. . . .

"Abdomen: Examination made through an incision from the umbilicus to the symphysis pubis. There is

Fig. 2-A

Fig. 2-B

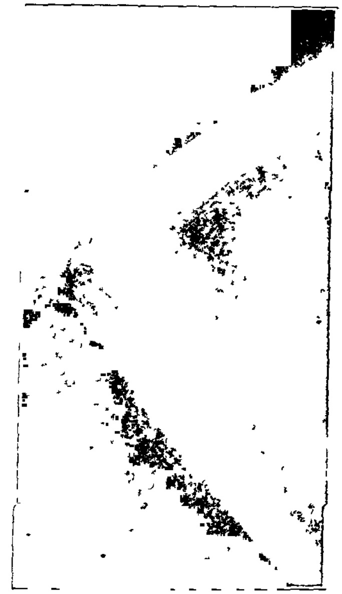

Fig. 3

Figs. 2-A and 2-B: Case 2. Anteroposterior and lateral roentgenograms show extensive destruction of femur with pathological fractures (eight years before death).
Fig. 3: Case 3. Destructive change in olecranon process.

a small amount of straw-colored fluid in the abdominal cavity and a few enlarged glands along the iliac vessels. Enlarged glands are present in the mesentery of the ascending colon. . . .

"The liver is normal in appearance and of normal size. No evidence of metastases can be discovered. The spleen is also normal in appearance and size. Both kidneys are somewhat enlarged.

"Left Lower Extremity: Incision along the lateral aspect of the thigh, from the anterior-superior spine to a point just below the knee. The tissues are everywhere oedematous. Little or no muscle remains beneath the fascia lata. An enormous mass, having the appearance of liver and containing numerous small, hard nodules, completely surrounds the femur. Lateral to the trochanter is the opening of a large cavity that leads to the pelvic cavity. The liver-like mass surrounding the femur is evidently an organized blood clot. About four inches below the trochanter is a fracture of the femur, split anteriorly, with some outward bowing. There is some displacement of the upper fragment. There is no evidence of callus. The entire femur is rough and somewhat smaller in diameter than would be expected. There are numerous flat, sharp spicules of bone, radiating outward from the periosteum like the spokes of a wheel.

"Surrounding the entire mass is a thick membrane, apparently the periosteum, which has been lifted away from the bone by the hemorrhage. Sections were taken from the upper and lower fragments of the femur.

"The femoral vessels are greatly thinned, being compressed between the fascia lata and the periosteum. There is no communication between them.

"*Anatomical Diagnosis:* Enormous organized subperiosteal hemorrhage involving the entire left femur, with overgrowth and absorption of bone. Secondary infection and ulceration of soft parts."

Case 2. A white man, aged fifty-one years at the time of his first admission to the Clinic on November 7, 1935, complained chiefly of a tumor of the right lower extremity and of inability to use the limb well since a fracture had occurred, three years before. In 1910, twenty-five years before admission, the patient had been kicked on the right thigh by a horse. The thigh swelled to about twice its usual size. This swelling lasted for two or three months, gradually subsiding; finally only a lump, three centimeters in diameter, could be felt on the medial aspect of the lower end of the thigh. This lump remained for about twelve years and then began gradually and painlessly to grow larger, until in 1932, three years before admission, the tumor had become about two-thirds its size on admission (twenty-five and one-half inches in circumference). In September 1932, as the patient roped a horse, the femur was fractured at the site of the swelling. He was treated by traction for sixty days. During this time there was some "discharge from the wound", but the wound healed. The patient was able to be up and about with crutches, but was unable to bear weight on the right lower extremity. The examination revealed a huge enlargement which involved two-thirds of the right thigh. The lesion was painful and quite tense. Roentgenograms (Figs. 2-A and 2-B) showed a peculiar destructive process, involving the lower half of the femur. The measurements of the two lower extremities were as follows:

	Right Lower Extremity (*Inches*)	Left Lower Extremity (*Inches*)
Length	37½	38¼
Circumference of thigh		
Upper	19⅜	17½
Middle	22¾	17
Lower	25½	14¾

The patient was found to have purpuric lesions of the skin.

The following laboratory findings were noted: hemoglobin 14 grams per 100 cubic centimeters of blood; erythrocytes 4,560,000 and platelet count 25,000 to 72,000 per cubic millimeter of blood. The coagulation time was fourteen minutes. A chest roentgenogram showed a "dense lobular mass, definitely intrathoracic, lying at the level of the fourth, fifth, and sixth ribs in the right axillary line, calcified, encapsulated empyema. Thickened pleura, right base, with diaphragmatic adhesions."

A needle biopsy of the tumor mass was performed on December 4, 1935, and necrotic hemorrhagic tissue was found.

A final diagnosis of purpura hemorrhagica was made and splenectomy was advised, but the patient refused this. Roentgen-ray treatments were given over the tumor, but at re-examination after a three-month interval no objective improvement was seen.

The patient later reported some improvement as a result of the roentgenotherapy. However, in March 1939, four years later, his wife wrote that "he had convulsions again, caused by the tumor on his leg". A letter from his wife, in April 1944, stated: "On September 2 the blood tumor on his leg broke and he died September 13, 1943. He practically bled to death. The leg was thirty-nine inches around." There was no postmortem examination.

Case 3. A white man, aged twenty-seven years, registered at the Clinic on August 8, 1929. He stated that his father and two cousins on his mother's side "bleed easily". The diagnosis of hemophilia had been made previously by the patient's uncle, a practising physician. The patient had had two severe hemorrhages from cuts and injuries. He had had a number of hemorrhages into the right elbow, which caused it to swell and to become painful after exercise.

Examination disclosed crepitation of the right elbow, especially on pronation and supination. Roentgenograms showed a cystic area in the right olecranon process with some irregularity of the joint surface (Fig. 3). The hemoglobin was 65 per cent. (Dare); erythrocytes 4,600,000 and platelets 172,000 per cubic millimeter of blood. The coagulation time was three minutes and the bleeding time two minutes.

No follow-up studies were obtained in this case.

Case 4. A white boy, aged nine years, first registered at the Clinic on January 21, 1932. Four weeks prior to admission, the patient had cut his right hand with a knife. The hand had been bandaged tightly, but hemorrhages had occurred four times, with the formation of hematomata in the palm of the hand. With the aid of four transfusions and dressings, bleeding was controlled and the wound healed.

The patient returned in April 1935. He had noticed a gradual enlargement of the right thumb over a period of eighteen months. A bluish discoloration had taken place (Figs. 4-A and 4-B). Roentgenotherapy was given over the affected thumb. The patient returned again in June 1937. There had been a gradual enlargement of the thumb. Examination revealed a thumb four or five times as large as normal, with a bulbous swelling of the terminal phalanx (Fig. 4-C). The swelling appeared cystic and seemed to contain a blood clot. An area three centimeters in diameter was apparent over the nail, which was black (Fig. 4-C). The coagulation time was twenty-four minutes, the erythrocytes numbered 4,130,000, and the platelet count was 91,000 per cubic millimeter of blood.

On July 2, 1937, the patient was given a transfusion of 150 cubic centimeters of citrated blood. The next day, amputation of the thumb was performed through the proximal end of the proximal phalanx. A large cystic cavity was noted in the bone, which was full of blood (Fig. 4-D). The bleeding points were easily caught and ligated. Very little bleeding occurred from the soft tissues. A pressure dressing was applied after closure of the wound. The hand was dressed in nine days and no bleeding was encountered. The patient was dismissed eleven days after the amputation. In November 1946, his sister wrote that he had had no more trouble with the thumb, but had had numerous hemorrhages of the joints, stomach, kidneys, and bowels.

Case 5. A white physician, aged thirty-seven years at the date of first registration, in July 1931, gave a family history of two brothers with hemophilia; of one brother, then dead, who apparently had had hemophilia; and of three paternal half brothers who were non-bleeders. The mother had four brothers who were bleeders, and all died of hemorrhages before the age of twenty-five years. The patient thought his maternal grandfather may have had hemophilia. The mother's sister's two sons had hemophilia, and another sister had one son who was a bleeder. Five sisters of the mother had sons who were non-bleeders. The patient had one daughter and one son who were not bleeders.

At the first admission the patient gave a history of repeated hemorrhages from the gums, nose, and so

Fig 4-A

Fig 4-B

Fig. 4-A: Case 4 Destruction of terminal phalanx of thumb at time of admission in 1935.
Fig. 4-B: Destruction of both phalanges of thumb in 1937.

Fig. 4-C

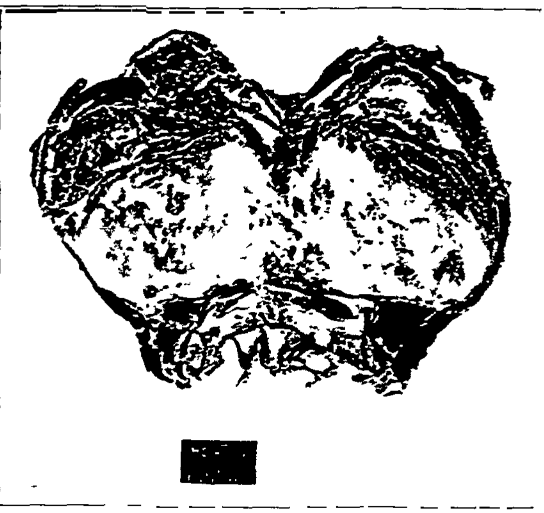

Fig. 4-D

Fig. 4-C: The thumb at time of admission in 1937.
Fig. 4-D: Specimen removed, the extensive blood clot within the expanded thumb should be noted.

rth, usually stopped by pressure. At that time the right knee was "stiff", but there was no history of ouble with the femur.

At the time of the patient's second admission, in April 1938, he was referred by a surgeon who stated at he had first seen the patient five months previously, after a fracture of the right femoral shaft. It was e opinion of the referring surgeon, as well as that of the patient, that the fracture was a combined traumatic id pathological fracture. The roentgenograms showed an area of considerably lessened density of the shaft the site of the fracture (Fig. 5-A). A cast was applied for ten weeks, but no callus developed and another st was applied. After another interval of about the same time no evidence of callus formation was noted, id there was evidence of actual erosion through the cortex. It was the opinion of the surgeon who referred ie patient that the lesion "may have been due to areas of hemorrhage within the shaft". The patient gave a story of frequent intramuscular hemorrhages within the thigh.

The patient returned at intervals of from one to three months during the next four and one-half years. At each visit a transfusion was usually given; a cast was applied to the extremity from the groin to the ankle, and over this a walking caliper brace was worn (Fig. 5-B).

At the time of his last admission, in November 1942, the patient stated that he had been fairly well until two months before, when something in the lower extremity seemed to give way; since then he had had continual pain and he could feel the fragments of the femur grate together. Finally blood began to seep through the cast, so he made a window in the cast and found an ulcer. He stopped work, received some plasma transfusions, and finally the bleeding from the ulcer was controlled. Further bleeding took place, and the patient received further transfusions of plasma. His general condition became worse and he felt weaker.

Examination on admission revealed two sinuses on the lateral aspect of the knee, with foul-smelling discharge and blood coming from them. Roentgenograms revealed almost complete destruction of the femur. Repeated transfusions were given, but the patient grew progressively worse and died thirteen days after admission.

The following excerpts are from the protocol of the postmortem examination: "The right knee is ankylosed at 180 degrees. There is an ulcer, measuring four by eight centimeters, over the lateral aspect of the lower third of the right thigh. The margins are covered with necrotic tissue [Fig. 5-C].

"This ulcer communicates directly with a large cavity, extending upward to the juncture of the upper and middle thirds of the femur and downward toward the knee. The anterior and lateral walls of the femur in its lower two thirds are absent. The edges are ragged and present a moth-eaten appearance. The marrow cavity is greatly expanded, with thinning of the cortex in a number of places. It is estimated that there are about 1,000 cubic centimeters of disintegrating clotted blood, apparently segregated in multiple loculi, particularly in the marrow cavity. The femur is fractured at the juncture of the middle and lower thirds, but the fragments are held together by a few bands of fibrous tissue. The right knee joint is also filled with disintegrating blood clots.

"The section of the cyst wall shows a fibrous periosteum in which a few vessels are present. The underlying cortical bone is thin, and in the marrow spaces normal bone marrow is replaced by loose connective tissue with numerous blood vessels. Osteoblasts and osteoclasts are greatly increased in number. Internal to the cortex there is a great increase in this connective tissue, which is extremely vascular. Numerous fibroblasts and young blood vessels are present, forming an irregular area of granulation tissue. In some areas the fibrous tissue is denser and surrounds spicules of bone which are undergoing degeneration. Intermixed with the granulation tissue are many macrophages containing pigment, some of which stain blue with the iron stain. Others are unstained and probably contain hematoidin.

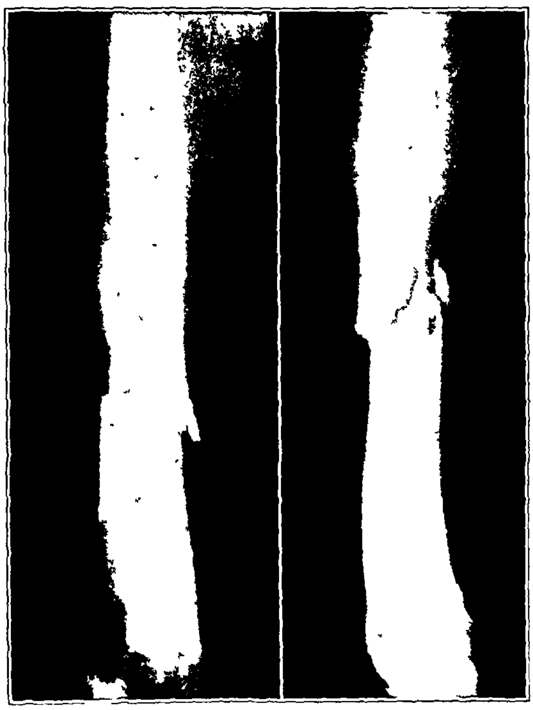

FIG. 5-A

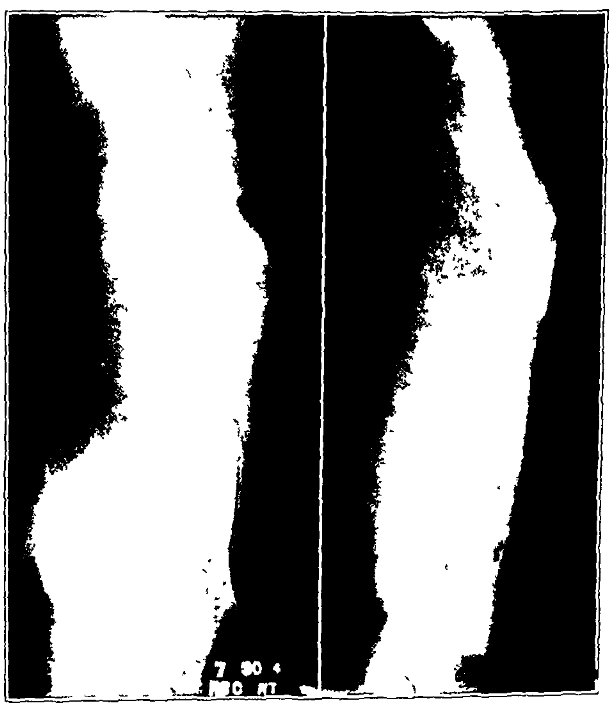

FIG. 5-B

Fig. 5-A: Case 5. Anteroposterior and lateral views of the femur, five months before admission in 1938.
Fig. 5-B: Appearance of femur four months before death of patient.
Fig. 5-C: Anteroposterior and lateral views of the femur, removed at necropsy. The bone was eroded extensively and surrounded by a mass of fibrous tissue.
Fig. 5-D: *a:* Section (× 20) made through margin of bone shows spicules of bone and fibrous tissue. *b:* Showing invasion of bone by fibrous tissue (× 115).

FIG. 5-D

FIG. 5-C

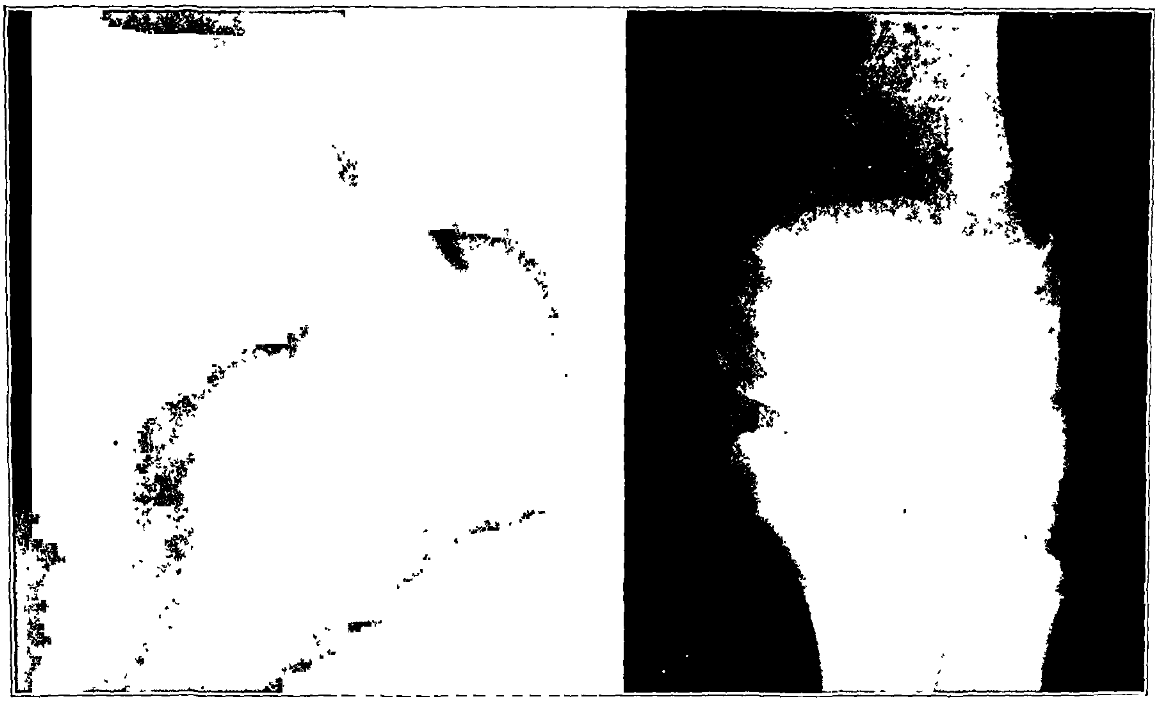

FIG. 6-A FIG. 6-B

Case 6. Lateral and anteroposterior views of small area of absorption in shaft of femur. Erosion may be noted on medial side of femur.

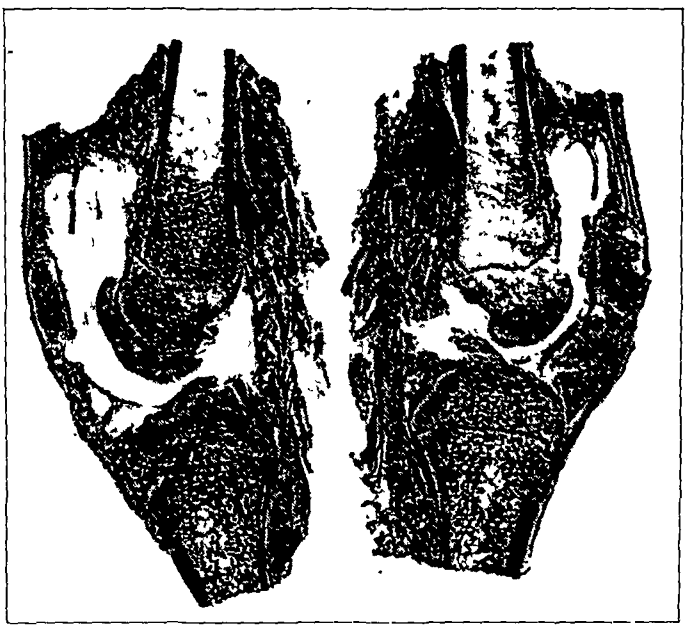

FIG. 6-C

Specimen shows extensive hemorrhage into knee joint and into marrow cortex of femur.

"Section of the bone near the fracture shows numerous trabeculae of bone with fragmentation of bone spicules; intermixed with them are areas of degenerating cartilage and solid masses of fibrous tissue, some of which is undergoing degeneration, also. The marrow is hyperplastic, with a great increase in all cell lines [Fig. 5-D].

"Sections of muscle at the fracture site show varying degrees of replacement of the normal muscle by fibrous tissue and, in other places, degeneration of the muscle cells with marked increase of myonuclei; in other areas there is actual necrosis of muscle cells. In surrounding areas and sometimes intermixed with the areas just mentioned are collections of macrophages, lymphocytes, and plasma cells; and associated with them are large numbers of cells containing both dark brown and light yellow pigment, corresponding to hemosiderin and hematoidin, respectively. In other areas of the muscle there is hemorrhage within the muscle tissue and necrosis of the muscle cells, giving the appearance of actual infarction of the muscle cells.

"Section of the skin, at the area of ulceration overlying the bone cyst, shows dense accumulations of granulation tissue, underlying thin epithelium which is apparently attempting to cover the granulation tissue. In the granulation tissue in this denser area are numerous macrophages which contain pigment; deeper in, towards the cyst, there is necrosis of tissue; and between that and the granulation tissue is a thin, irregular grouping of neutrophils, as well as lymphocytes, plasma cells, and macrophages."

CASE 6. A boy, ten years old, first registered at the Clinic in 1928, complaining of pain and swelling of several joints, which had been present for eight years. A second admission in 1929 and a third in 1934 were noted, but no specific treatment was given. He returned in 1937, with the recommendation of a dentist in his home community that he have three teeth extracted. One tooth was extracted, but the patient's bleeding

could not be stopped in spite of transfusions, administration of neohemoplastin, epinephrine packs, and so forth. On the fourth day the patient died.

Roentgenograms taken in 1931 showed a destructive area in the lower portion of the left femur (Figs. 6-A and 6-B). On postmortem examination the oval area of rarefaction in the cortex of the distal third of the femur was found to be the site of a hemophilic bone cyst which had developed during the previous six years. Figure 6-C shows the knee almost completely filled with old hemorrhage. The joint synovial membrane was grossly thickened and darkened, and showed evidence of hemosiderin deposits in many places. Hypertrophied synovial tags extended into the intra-articular spaces, and in some places the joint cartilage was markedly thinned.

DISCUSSION

The six cases reported here in some detail seem to be examples of the so-called hemophilic pseudotumor. These cases are similar to those previously noted in the literature. One, Case 4, is very similar to that reported by Firor and Woodhall. In one other case the olecranon was involved; unfortunately, we have been unable to trace this patient and cannot tell what changes have developed. In four cases the lesion involved the femur, and all of these patients are now dead. Three died from the effects of the pseudotumor of the thigh with subsequent fracture of the femur, erosion of the mass through the skin, and terminal hemorrhage with infection. In Case 6 the patient died of hemorrhage following a tooth extraction, but the changes in the roentgenogram and the findings at necropsy would indicate the beginning of a process similar to those which developed in the other cases of "pseudotumor" of the thigh.

We have already stated that it is impossible for us to determine whether these hematomata were extensions of hemorrhage from a neighboring joint, or were subperiosteal or intramedullary in their origin. The case of the physician, which was followed most closely and over the longest period of time, would indicate that the hemorrhages, at least in this case, were intramuscular and subperiosteal and caused destruction of the bone more by pressure erosion than by any other action. It is impossible for us to state whether or not there may be any "chemical effect", as postulated by Reinecke and Wohlwill.

Müller reported the results of roentgenotherapy in two cases (one of these was Becker's first case, already cited), and arrived at the conclusion that irradiation had influenced the resorption tumor primarily by changing the reaction of the reticulo-endothelial system, as well as by influencing the products of cell destruction. Others have maintained that the roentgen rays influence the constitution of the blood. In the one patient in this series who was treated by roentgenotherapy, no improvement was noted.

CONCLUSIONS

On the basis of the cases reported, it would seem reasonable to conclude that these pseudotumors may arise, first, from hemorrhages originating in the joint, extending along the bone to produce pressure erosion; second, from subperiosteal hemorrhages, which may at first lead to formation of new bone and later to absorption and destruction of bone; and third, from cortical or medullary hemorrhage, which may lead to cystic changes and later may destroy the bone or lead to fracture and further hemorrhage.

It is difficult in any one case to state accurately which route was followed. On the other hand, it seems important to be able to recognize the condition early enough so that the destructive changes may be kept under control.

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DISCUSSION

DR. WILLIAM T. GREEN, BOSTON, MASSACHUSETTS: We are indebted to Dr. Ghormley and Dr. Clegg for focusing our attention upon the skeletal complications of hemophilia, and particularly for presenting the bizarre picture of pseudotumor as one of the more rare lesions in the disease.

Of the major complications secondary to hemophilia, those of the skeletal system are most frequent and often most serious. The "hemophilic joint" is familiar to us all,—repeated acute episodes of hemorrhage into a joint, progressive degeneration of the articulation, and increasing disability. Each episode of hemarthrosis increases the pathological process in the joint, which in turn, with its progression, increases the likelihood of recurrent hemorrhages.

Another less common musculoskeletal manifestation, which should be emphasized particularly in relation with pseudotumor, is that of massive acute hemorrhage beneath the deep fascia, with impairment of the circulation distal to the area of hemorrhage. We have seen several instances of Volkmann's contracture, affecting either the upper or lower extremity. In one patient in this category, with whose record we are familiar, amputation was necessary because of gangrene of the foot.

In all of these complications—the hemophilic joint, Volkmann's contracture, and pseudotumor—the tendency is to develop an interest in the process at too late a stage in its evolution. Hemorrhage into the joint of a patient with hemophilia warrants attention at the start, as does any considerable degree of bleeding beneath the deep fascia. On these occasions, the clotting time should be brought down and kept down until the acute episode has passed. The most effective way to do this is by small transfusions of blood or plasma, which should be fresh, not stored. These may be necessary as often as every six hours, as guided by the venous clotting time.

One of the fractions of plasma, obtained by the process of Cohn and his associates, the so-called fraction 1, has been found by Diamond to be approximately ten times as active as plasma in reducing the clotting time. However, considerable difficulty has been encountered in preparing the fraction so that it is dependable. It is not available on a commercial basis, but it is a step in the right direction.

Local measures affecting the part are likewise important; a judicious choice must be made as to the use of rest, traction, immobilization of short duration, motion, and gradual resumption of activity. If any considerable amount of blood is present in a joint, aspiration and irrigation are indicated, once the clotting time has been reduced to normal limits.

The pseudotumor, in its full-blown character described by the authors, I have not seen. Its mechanism in most of its phases seems evident, and illustrates the tendency for hemorrhage to recur after a certain stage in the local process has been established. This adds emphasis to the idea that attention should be given to these local processes before it is too late. Concealed hemorrhage of any considerable amount should be considered as much of an emergency as "open hemorrhage".

DR. GUY A. CALDWELL, NEW ORLEANS, LOUISIANA: The report of Dr. Ghormley and Dr. Clegg adds six cases with unusual bone changes to the small group of similar cases heretofore reported.

The authors state that "it is impossible for us to determine whether these hematomata were extensions of hemorrhage from a neighboring joint, or were subperiosteal or intramedullary in their origin". Other cases that have been reported have shown, in their roentgenograms, areas of absorption and rarefaction in the epiphyses and diaphyses of various bones. Dr. Key believes that these are the result of intra-osseous hemorrhage. Most observers raise the question as to whether or not hemophilic blood contains some particular element which is peculiarly destructive to bone and cartilage, but no one, thus far, has identified such an element. From the viewpoint of diagnosis and treatment, it is important to bear in mind that joint changes and bone changes are frequent in cases of hemophilia. The lesions may closely simulate the changes seen in chronic arthritis and, when they occur on the shafts of bones, may be mistaken for osteogenic tumors.

Errors in diagnosis and treatment are not likely to be made when the patient gives a clear-cut history of prolonged bleeding from minor cuts and of similar tendencies in other members of the family. However, the delay in coagulation is the only abnormal factor in the blood of such patients and, since it may be almost normal at times, more than one test should be carried out when there is reasonable question of hemophilia. The blood should be drawn from the vein rather than from the lobe of the ear or the fingers, because, when mixed with tissue juices, the coagulation time may be quite normal. The etiological factor responsible for the de-

(Continued on page 630)

COXA PLANA *

BY M. BECKETT HOWORTH, M.D., NEW YORK, N. Y.

Coxa plana is a disease of the hip, usually occurring between the ages of four and ten years, and running a self-limited course. It is characterized by degenerative changes in the epiphysis of the femoral head, due to a circulatory disturbance. The name coxa plana is not altogether satisfactory, as it does not include the earliest stage or all the changes of the disease, but it is the best name so far suggested. The condition is also known as Legg-Perthes disease or Calvé's disease, osteochondritis deformans juvenilis, and aseptic necrosis of the upper femoral epiphysis. The term aseptic necrosis is not accurate for describing either the pathological or roentgenographic features of the disease, and should be discarded. Coxa plana is one of a group of diseases, the osteochondroses, which include slipping of the upper femoral epiphysis, coxa magna [2], Osgood-Schlatter disease, apophysitis of the calcaneus, Köhler's disease, Freiberg's disease, Kienböck's disease, and epiphysitis of the spine (Scheuermann's disease). They are all characterized by degenerative changes, due to circulatory disturbance, but occur at various ages in various epiphyses or small bones. The age differences of the osteochondroses are explained by the varying vulnerability of the local circulation at different ages. Degenerative changes similar to those of coxa plana may be produced, however, by circulatory damage at other ages,—for example, after slipping of the upper femoral epiphysis or fracture of the femoral neck.

Coxa plana is frequently encountered in orthopaedic practice, some 115 cases having been seen in various stages of the disease at the New York Orthopaedic Hospital during the ten years from 1935 to 1944, inclusive. A careful study of these cases has been made, and forms the basis for this report. An earlier report was made by Ferguson and Howorth in 1934[1].

CLINICAL FEATURES

Coxa plana is more common in boys than in girls (85 per cent. in boys, 15 per cent. in girls); the reason for this is not known. It is unilateral in 90 per cent. of the cases, and occurs about as often in one hip as in the other. The physical type of the child appears to have no relation to the disease, and only an occasional case presented a definite endocrine disturbance. Coxa plana may occur during the course of treatment of congenital dislocation of the hip in about 25 per cent. of the hips, as a result of immobilization in a position of tension, particularly extension, abduction, and internal rotation. This position "wrings out" the blood vessels and interferes with the circulation, resulting in degenerative changes. The capsule and vessels are most relaxed at 90 degrees of flexion in the neutral lateral and rotary positions.

ETIOLOGY

The cause of coxa plana is not definitely known. Occasionally it is present in more than one child in a family, but no definite familial or hereditary relationship has been found. There is little or no evidence to favor the hypothesis that it is due to a congenital abnormality. Trauma apparently is usually an incidental factor, aggravating the disease rather than provoking its onset. Infection has not been demonstrated by culture or microscopic sections of tissue taken from the hip, although there are gross and microscopic mild inflammatory changes. Respiratory and other infections have been present just prior to the onset of the hip symptoms in a number of instances. It is possible that an allergic reaction in the soft tissues of the hip, due to infection elsewhere, may cause the vascular

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 28, 1947.

FIG. 1-A

Case illustrating typical changes of coxa plana, in a child of five years. An early diagnosis was made. Treatment by complete bed rest for nine months had little, if any, effect on the course of the disease or the resultant deformity. Pain and limp had been present for one week, with slight limitation of all motions, and pain and spasm at extremes. Then bed rest was begun.

March 26, 1945. Earliest signs of coxa plana: The capsule is swollen. There is decalcification distal to the epiphyseal line. The crest of the head is flat; slight irregular ossification is present. There is slight widening of the joint space, superiorly and medially.

FIG. 1-B

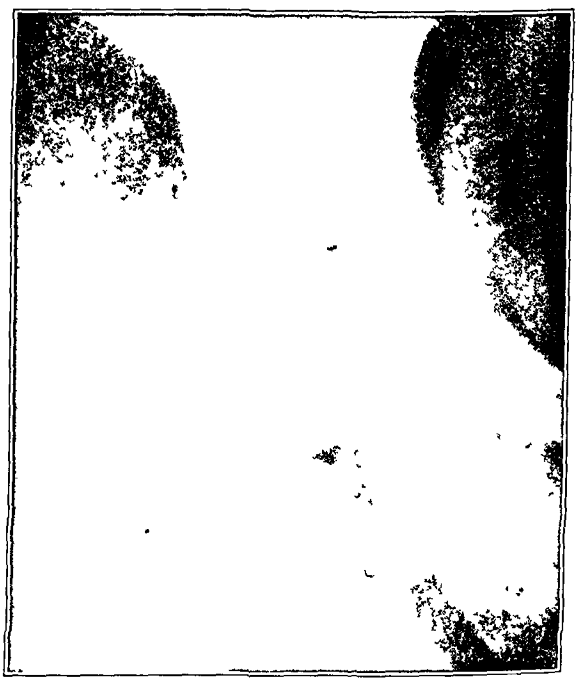

FIG. 1-C

Fig. 1-B: Sept. 11, 1945. Six months after onset, the epiphyseal line is wider, with irregular decalcification on the distal side. Early decalcification of head is seen laterally. The articular surface of the head is irregular.

Fig. 1-C: Nov. 13, 1945. Eight months after onset, the head is flatter and thinner, with early decalcification medially, more decalcification toward the lateral aspect, and increased density centrally. The epiphyseal line is healing.

changes. The endocrine glands have been blamed for the disease, because about one third of the patients are of the fat and flabby type, but no definite evidence has been produced to prove the connection or to explain the fact that coxa plana is usually limited to one hip. The basal metabolic rate has usually been normal. Cretinoid epiphyseal dysgenesis, due

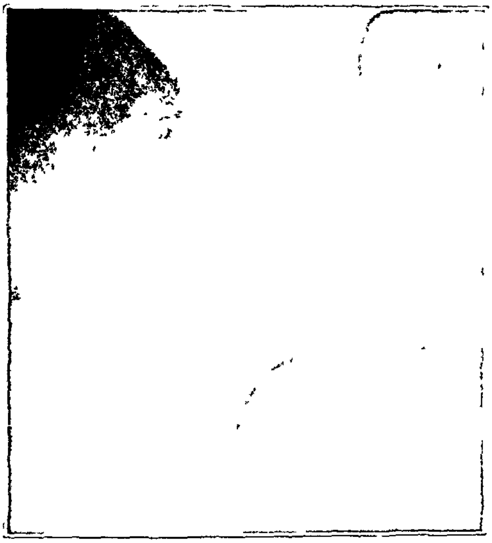

Fig. 1-D

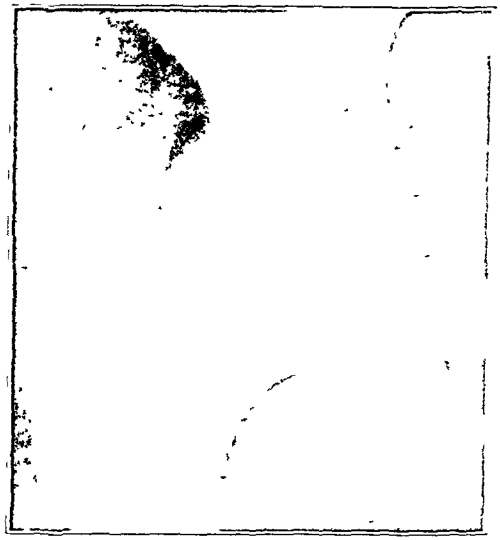

Fig. 1-E

Fig. 1-D: Jan. 17, 1946. Ten months after onset, the head is still flatter and thinner, with more decalcification medially and laterally, and central condensation. Ossification is more irregular. Slight subluxation has occurred. The epiphyseal line has healed. The proximal surface of the neck is convex, growing into the head.

Walking is resumed at this time.

Fig. 1-E: Apr. 23, 1946. At the end of thirteen months, the head is flatter and thinner, ossification is more irregular, and there is increased density at the center. Recalcification has taken place medially and laterally. The neck is broader.

Fig. 1-F

June 18, 1946. After fifteen months the head is flatter and thinner, more dense at the center. The neck is wide.

to hypothyroidism. is similar to coxa plana, but should not be confused with it. Changes similar to those found in coxa plana are seen also in the hips of a good many children with achondroplasia, chondrodysplasia, juvenile rickets, and Morquio's disease.

Coxa plana is fundamentally a vascular disturbance with resultant degenerative changes in the head of the femur. The vascular disturbance may be due to any one of several causes.

FIG. 1-G

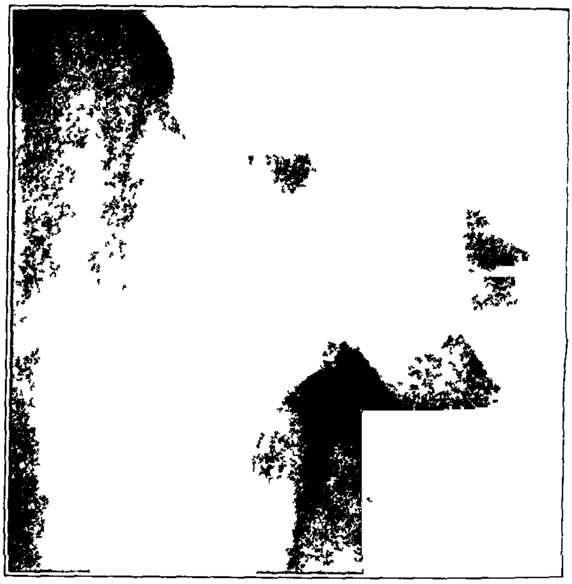

FIG. 1-H

Fig. 1-G: Sept. 10, 1946. After eighteen months, the head is very flat and thin, the center less dense This is the *end of the absorptive phase.* The capsule is not swollen

Fig 1-H: Nov. 18, 1946 At the end of twenty months, the central area of the head is beginning to recalcify, the medial and lateral portions are well ossified.

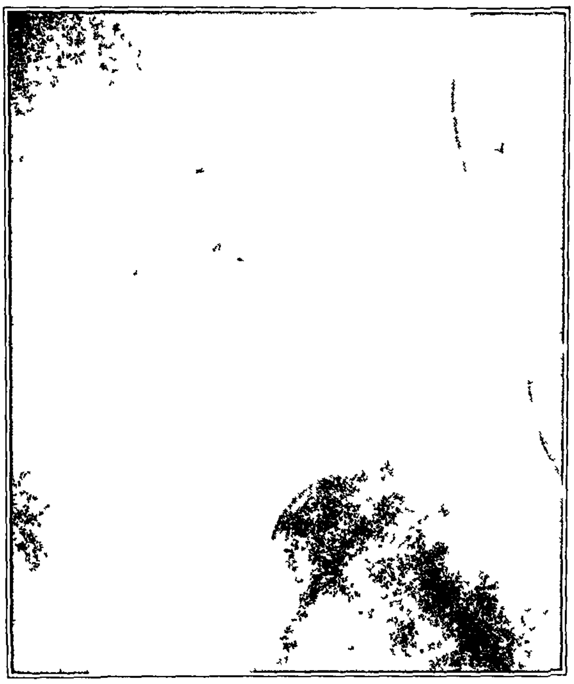

FIG 1-I

Jan. 21, 1947. Twenty-two months after onset, the central area is more evenly calcified

PATHOLOGICAL FINDINGS

The pathological changes in coxa plana have been studied at operation on fifty hips in early and late cases. Changes occur early in the soft tissues, the synovial membrane, the capsule, and the periosteum. These tissues are swollen, oedematous, and hyperaemic, especially the synovial membrane, which is usually redundant at the inferior angle between the head and neck. Microscopically, there is oedema, hypervascularity, and thickening of the synovial membrane, often with villous formation (Figs 3-L, 4-K, and 5-G). Perivascular lymphocytic and plasma-cell infiltration are usual. There is softening on the distal side of the epiphyseal disc, due to decalcification and increased vascularity (Fig. 5-H). Soon dense areas appear in the femoral head, due to bone condensation or increased calcification Later these dense areas are invaded by blood vessels and granulation tissue which tend to absorb them; and there may be areas containing very little bone. At this time the head tends to become flattened and wider, and the neck becomes relatively shorter and thicker In the meantime, the soft tissues become less vascular and oedematous; scarring and inelasticity develop; and a pannus appears at the margin of the head. Hyperplasia of the tissues in the region of the Haversian gland results in some lateral displacement of the femoral head in the acetabulum. As the disease recedes, the bone recalcifies,—first at the epiphyseal disc, later in the softened areas of the femoral head, which eventually fill in and become trabeculated. However, the head maintains its mushroom shape. As a result of the deformity, the head does not fit the acetabulum well and tends to become subluxated, whereas motion is mechanically less smooth. The acetabulum tends to become deformed,

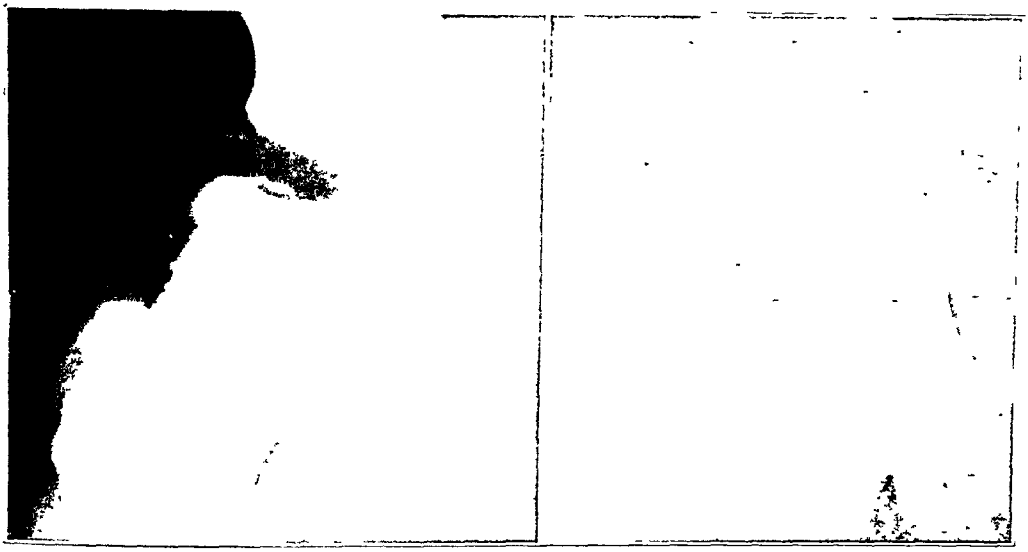

FIG. 1-J

May 1947. At the end of twenty-six months, further ossification of central area is evident.

adapting itself somewhat to the deformity of the head.

Stages of Disease

Coxa plana may be divided into: (1) the early or incipient stage, lasting several weeks, in which there are only soft-tissue changes and mild symptoms and signs associated with the synovitis; (2) the degenerative or active stage, lasting one or two years, in which degeneration in the head and softening at the epiphyseal disc occur; (3) the healing stage, lasting three or four years, in which the dense areas are replaced by granulation tissue and finally by normal bone, while the soft tissues become sclerotic and the symptoms and signs of synovitis disappear; and (4) the residual stage, in which only the deformity with its consequent symptoms remains. In each stage the soft-tissue changes precede the bone changes.

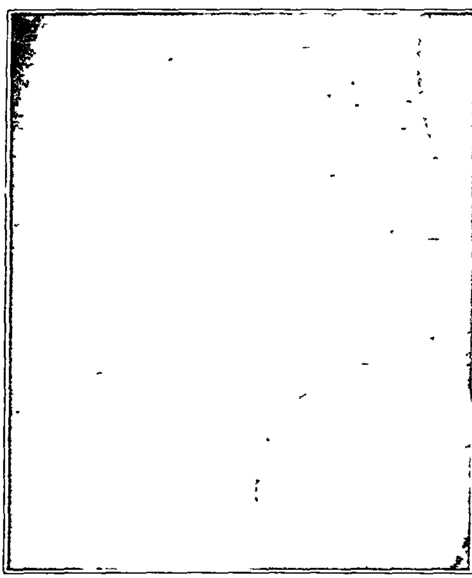

FIG. 1-K

Sept. 20, 1947. Thirty months after onset. There has been no definite change since May 1947. The head is quite thin and flat; the head and neck are broad, so that one quarter of the head projects beyond the acetabulum.

Symptoms

In the early stage, the most common symptom is a slight limp, which increases with the intensity of the disease. Pain is usually complained of, but is rarely severe enough to prevent walking; often it is only a mild ache or stiffness. The pain is referred to the groin, medial aspect of the thigh, or knee, and follows the distribution of the obturator nerve. The pain is apt to be worse with activity and to be relieved by rest; it usually begins gradually, and is often aggravated by some trivial injury. Occasionally limitation of motion is noticed. There may be disability for vigorous activity.

The acute symptoms gradually subside during the later stages, and are replaced by symptoms due to the faulty mechanics associated with the deformity. There may be a

FIG. 2-A

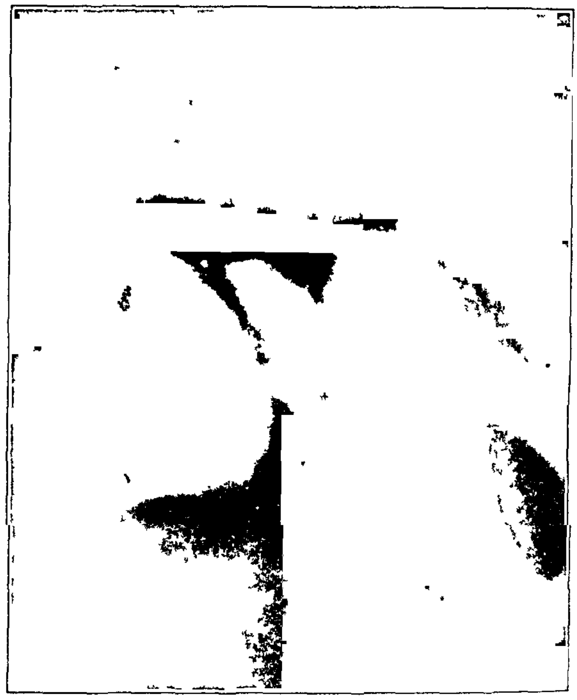

FIG. 2-B

FIG 2-C

FIG. 2-D

FIG. 2-E

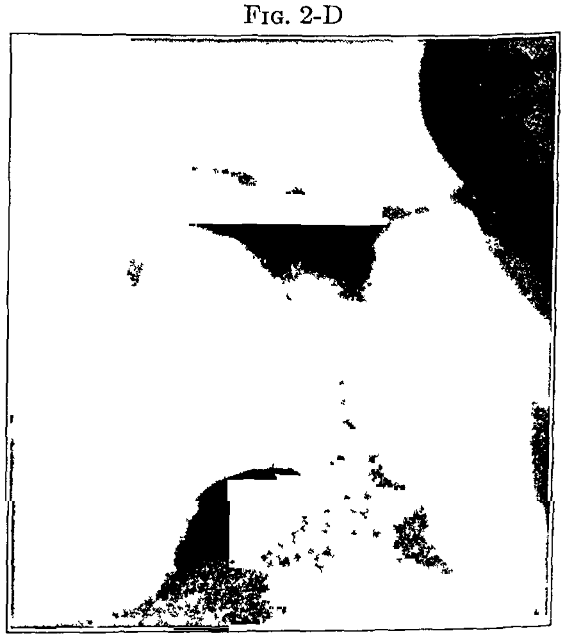

FIG. 2-F

slight limp, due to shortening and limitation of motion, slight pain on vigorous activity, slight stiffness and disability. Eventually the symptoms of osteo-arthritis may supervene.

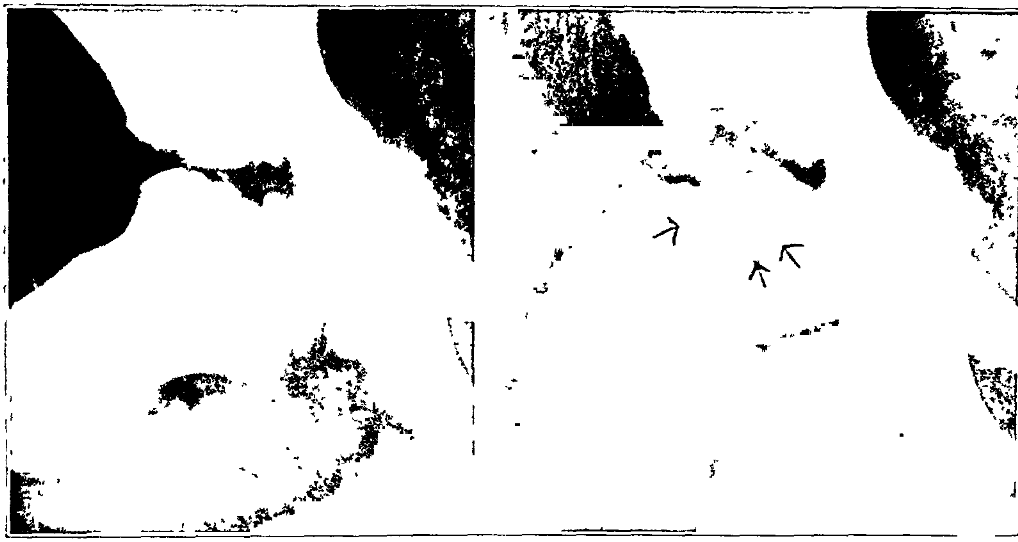

Fig. 2-G

Fig. 2-H

Typical case of coxa plana, in a child of four and one-half years, treated with a sling and crutches. An early diagnosis was made. Pain and limp had been present for three weeks. All motions were limited by pain and spasm. Healing was not complete after four years without weight-bearing.

Fig. 2-A: Oct. 20, 1943. The capsule is swollen. The head is smaller and thinner than normal, irregularly ossified, and the articular surface is uneven. The joint space is wide, superiorly and medially. The patient was kept in bed for two months, then a sling and crutches were used.

Fig. 2-B: Mar. 29, 1944. Five months after onset, ossification of the head is more irregular and dense. The epiphyseal line is wider, with decalcification at the junction with the neck.

Fig. 2-C: Oct. 2, 1944. After one year, ossification of the head is more irregular, especially posteriorly. The head is more dense centrally. The neck is wider. The epiphyseal line is healing. The proximal surface of the neck is convex, growing into the head.

Fig. 2-D: Jan. 3, 1945. At the end of fourteen months, ossification of the head is more irregular, with absorption anteriorly. The head is flat anteriorly, thin, and broad. The epiphyseal line has healed.

Fig. 2-E: Feb. 13, 1946. After twenty-eight months, the anterior half of the head has been absorbed, except for a small island; the posterior half is ossifying and filling in. This is the *end of the absorptive phase*.

Fig. 2-F: Sept. 23, 1946. After three years, slightly more filling in is seen. Weight-bearing is begun.

Fig. 2-G: By Oct. 8, 1947, the posterior half is nearly healed, but there is no filling anteriorly. Compare with anteroposterior view (at right). The head is broad, thin, and flat. The neck is broad. Slight subluxation has occurred.

Fig. 2-H: Jan. 24, 1948. Slight further healing.

Signs

The earliest and most important signs of the disease are the limp, limitation of motion, and pain at the extremes of motion, especially lateral motion and rotation. The limitation, pain, and spasm increase in proportion to the intensity of the disease. There may be slight tenderness anterior to the hip joint. In time, slight atrophy of the thigh and slight shortening of the femur appear, due to the flattening of the head and shortening of the neck. The limp at the beginning is due to pain and spasm, later to limitation of motion and shortening.

LABORATORY FINDINGS

Laboratory tests are of only incidental value in this disease. The erythrocyte sedimentation rate is usually increased slightly; it averages 25 millimeters per hour and may go as high as 40 millimeters, indicating to some extent the intensity of the disease. The blood count, serum calcium, phosphorus, phosphatase, and basal metabolic rate are usually normal. Cultures of the synovial fluid and of material taken from the synovial membrane and the bone have been negative.

ROENTGENOGRAPHIC FEATURES

The first evidence of the disease in the roentgenograms is a globular swelling of the capsule (Figs. 1-A, 2-A, 3-A, 4-A, and 5-A). The joint space appears wider medially, because of a slight subluxation laterally (Figs. 1-A, 2-A, 3-A, 4-A, and 5-A). It appears wider superiorly, because of a flattening of the ossified portion of the epiphysis; but there is no change in the shape of the articular cartilage at this stage (Figs. 1-A, 2-A, 3-A, 4-A, and 5-A).

Soon after the onset, the epiphyseal line appears wider and is irregularly decalcified at its junction with the neck (Figs. 1-A, 2-A, 2-B, 3-A, 4-A, and 5-B). An irregular dense area soon appears in the capital epiphysis, usually in the central portion (Figs. 1-C, 2-C, 3-A, 4-A, and 5-B). Gradually the dense area becomes irregularly decalcified, but it may enlarge at the same time (Figs. 1-C to 1-G, 2-C, 2-D, 3-A to 3-D, 4-C, and 5-B to 5-D). During the decalcification, the head becomes wider, flatter, and thinner, and the neck becomes thicker and shorter. In some hips the affected area assumes the characteristics of osteochondritis dissecans. Gradually the soft-tissue swelling subsides; the epiphyseal line recalcifies, while the proximal surface of the neck becomes convex and grows into the head (Figs. 1-G, 2-D, 3-D, 4-D, and 5-D). More gradually, the decalcified areas are recalcified (Figs. 1-H, 2-F, 3-F, 4-G, and 5-E). Eventually normal trabeculation occurs, but the head maintains its mushroom shape and tends to remain subluxated; one-fourth to one-half of the head projects lateral to the acetabular margin, due to its enlargement (Figs. 1-J, 2-G, 3-K, 4-J, and 5-F). The shape of the acetabulum usually follows somewhat the shape of the head (Figs. 1-H, 2-F, 3-F, 4-G, and 5-E). Osteo-arthritic changes often develop in middle life, but these are usually not so severe as those with slipping of the upper femoral epiphysis, probably because of greater mechanical and physiological disturbance in the latter.

DIFFERENTIAL DIAGNOSIS

Any child between the ages of three and twelve years who complains of a limp and pain in the groin, the anterior or medial aspect of the thigh, or the medial side of the knee, should be suspected of having coxa plana. The hip should be carefully examined for limitation of motion and for pain and spasm during motion, and roentgenograms should be taken. In case of doubt, the child should be put to bed until physical signs disappear and subsequent roentgenograms reveal no evidence of coxa plana.

The typical roentgenographic changes of coxa plana are rarely seen with the other

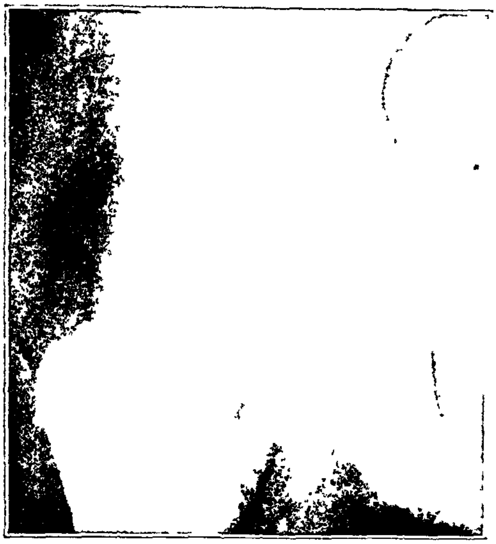

FIG. 3-A

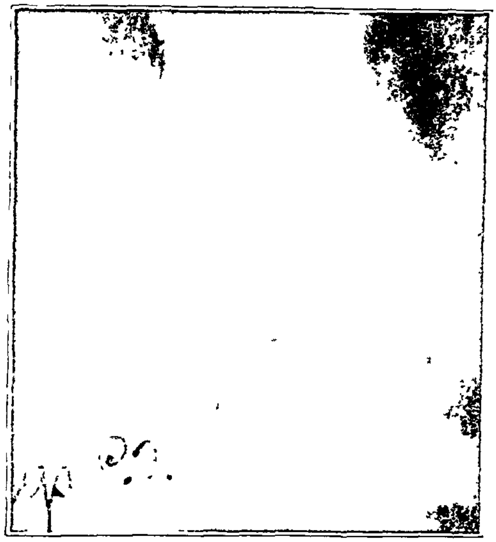

FIG. 3-B

Typical coxa plana in a child of three years, treated by bed rest for nineteen months and drilling (twice). This treatment had little, if any, effect on the course of the disease or on the deformity. Drilling with an awl probably was not effective, the child probably walked too soon. An early diagnosis was made. Limp and pain had been present for three months. All motions were slightly limited, there was moderate spasm at the extremes, and pain.

Fig. 3-A: July 30, 1931. The capsule is swollen. The epiphyseal line is wide and decalcified, especially at the margins. The neck is slightly wide. The head is flat, the articular surface is uneven and irregularly ossified with central condensation. The joint space is wide superiorly and medially.

The patient was treated by bed rest for one month before operation. On Aug. 27, 1931, Operation I was carried out. Six holes were drilled in the head with an awl.

Fig. 3-B: On Aug. 30, 1931, the epiphyseal line is wider and irregularly decalcified. The head is flatter, thinner, and more dense.

FIG. 3-C

FIG. 3-D

Fig. 3-C: Dec. 3, 1931. Three months after operation, the head is denser, especially at the center, thinner, and flatter. The epiphyseal line is more irregular and decalcified. There is slight subluxation.

Fig. 3-D: Jan. 26, 1932. At the end of five months, the head is less dense, thinner, flatter, and is ossifying medially. The epiphyseal line is healing. The neck is convex and is growing into the head.

childhood diseases of the hip, such as suppurative arthritis, osteomyelitis, rheumatic fever, and slipping of the upper femoral epiphysis. These diseases may be further distinguished by their clinical features and the familiar laboratory tests. Coxa plana may occur in the course of treatment of congenital dislocation of the hip.

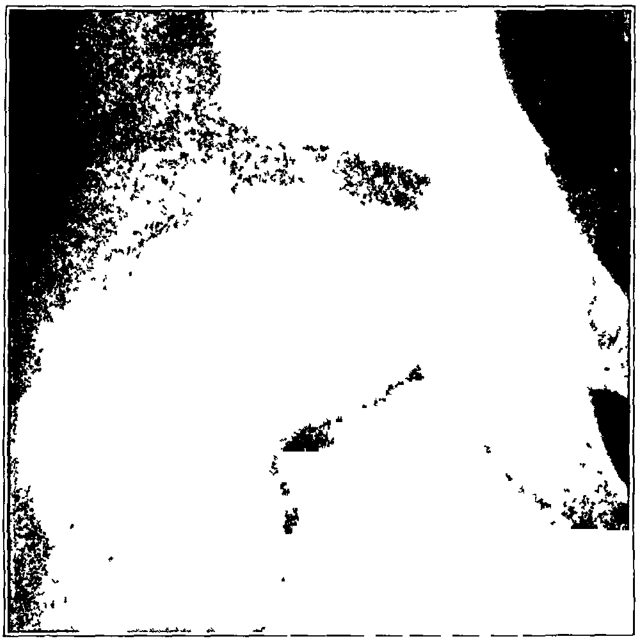

FIG. 3-E

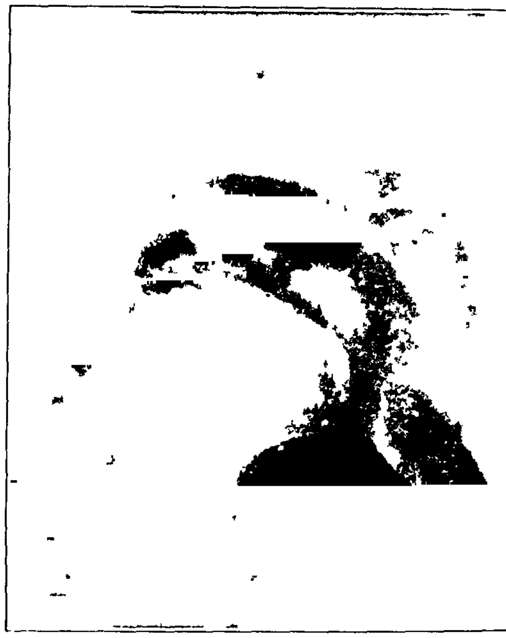

FIG. 3-F

FIG 3-G

FIG 3-H

FIG. 3-I

FIG. 3-J

Fig. 3-E: June 22, 1932. After ten months the lower two thirds of the head are largely decalcified, leaving only small islands of bone. The line has healed. This is the *end of the absorptive phase.*

Operation II was performed on Aug. 22, 1932. Six holes were drilled in the head with an awl.

Fig. 3-F: Feb. 4, 1933. At this time, eighteen months after Operation I and six months after Operation II, the head is beginning to reossify. Growth of bone has proceeded from the neck across the epiphyseal line into the head. The capsule is not swollen.

Walking was begun, perhaps too soon.

Fig. 3-G: May 4, 1933. The head is filling in; the medial and lateral portions are healed.

Fig. 3-H: Oct. 3, 1933 (twenty-six months after Operation I and fourteen months after Operation II. Further filling in of the central portion of the head and ingrowth from the neck have taken place.

Fig. 3-I: Mar. 21, 1934 (thirty-one months after Operation I and nineteen months after Operation II. Shows further filling in.

Fig. 3-J: Nov. 10, 1934 (thirty-nine months after Operation I and twenty-seven months after Operation II). The head has filled in, but ossification is uneven. The head is wide, thin, flat, and subluxated. one third is outside the acetabulum. The neck is wide.

Fig. 3-K: Oct. 26, 1935 (four years and two months after Operation I and three years and two months after Operation II). The head is filled in and evenly ossified.

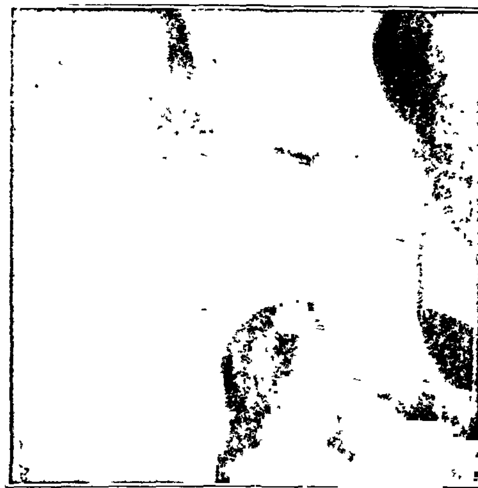

Fig. 3-K

Fig. 3-L

At operation on Aug. 27, 1931, the synovial membrane showed marked hypervascularity, moderate oedema, and the presence of villi. A few plasma cells and large mononuclear wandering cells (histiocytes) are seen.

COURSE IN UNTREATED CASES

Coxa plana follows a characteristic course over a period of four to seven years, and always heals, but with some residual deformity. There is considerable variation among individual cases in all features of the disease, especially in the roentgenographic changes

FIG. 4-A

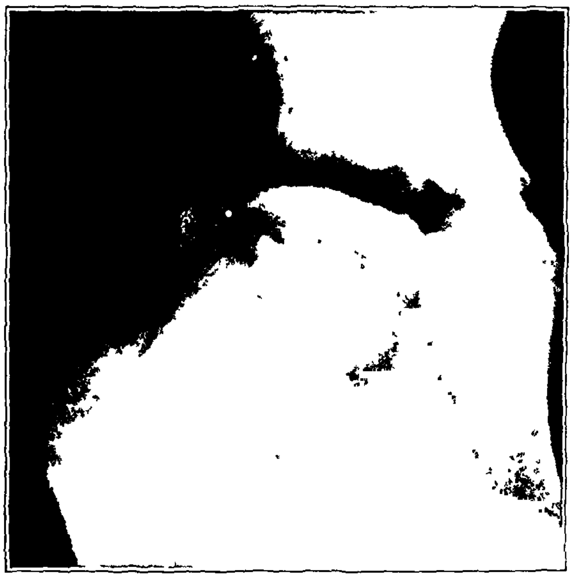

FIG. 4-B

Typical coxa plana, with early diagnosis, in a child of seven years, treated with drilling operation. Pain had been present for two months. Other symptoms included limp, considerable limitation of motion, pain, and spasm.

Good healing had taken place by four years after onset—less than the average time—despite no treatment during the first fifteen months and extensive involvement.

Fig. 4-A: July 16, 1930. Two months after onset, the capsule is swollen. The epiphyseal line is wide,

FIG. 4-C

FIG. 4-D

FIG. 4-E

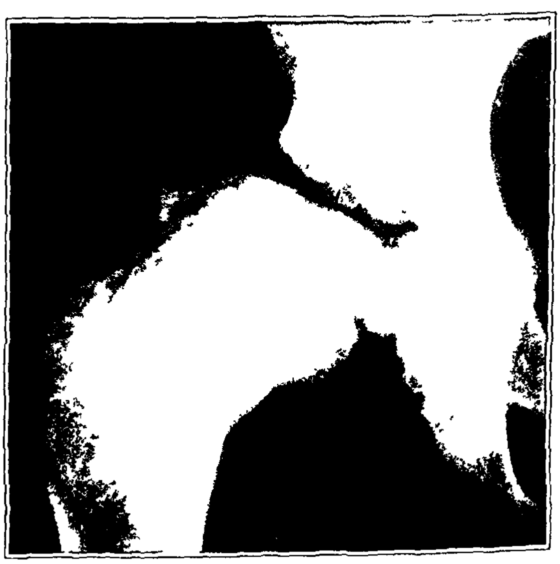

FIG. 4-F

Fig. 4-G

Fig. 4-H

Fig. 4-I

with decalcification at the junction with the neck; the neck is wide. The head is flat superiorly; the articular surface is uneven; ossification is irregular; density is increased. The joint space is wide.

No treatment was given for fifteen months.

Fig. 4-B: Dec. 1, 1930. After seven months, the head is flatter, thinner, denser, and more irregularly ossified. The epiphyseal line is wider, more irregular, and decalcified. Slight subluxation is shown.

Fig. 4-C: Mar. 2, 1931. Ten months after onset, the head is still flatter, thinner, and more irregularly ossified. The epiphyseal line is beginning to reossify. One third of the head is outside the acetabulum.

Fig. 4-D: Oct. 14, 1931. After seventeen months, the lateral portion of the head is almost absorbed. The epiphyseal line has healed. This is the *end of the absorptive phase.*

At operation, on Oct. 22, 1931, six holes were drilled. The patient remained in bed for four months, then was ambulatory in a short spica for two months.

Fig. 4-E: Nov. 16, 1931. At eighteen months (one month after operation), no dense areas are seen. The head is filling in and is rounder, but irregularly ossified. The neck is growing into the head. The capsule is not swollen.

Fig. 4-F: Feb. 8, 1932. At twenty-one months (four months after operation), more filling in is seen. Ossification is more even. Half of the head is outside the acetabulum.

Fig. 4-G: Nov. 5, 1932 (thirty months after onset and thirteen months after operation). The head is more evenly ossified.

Fig. 4-H: Apr. 8, 1933. Three years after onset and eighteen months after operation, further ossification of the head is shown.

Fig. 4-I: Sept. 15, 1934 (four years after onset and three years after operation). The head is well ossified, but flat, thin, and broad. The neck is broad and has grown into the head. The course was probably shortened by drilling, but drilling might have been done earlier with more benefit.

and course. For this reason it is very difficult to set up a standard for evaluating the effect of treatment, particularly in individuals or in small groups of cases.

TREATMENT

Rest

The primary treatment for coxa plana at the present time is rest. Rest in bed is the surest and simplest way of securing rest for the hip, but it must be continued for two or three years from the onset in the average case. Bed rest alone has been used in about thirty cases of this group (Figs. 1-A to 1-K). Rest allows recovery of the circulation of the soft

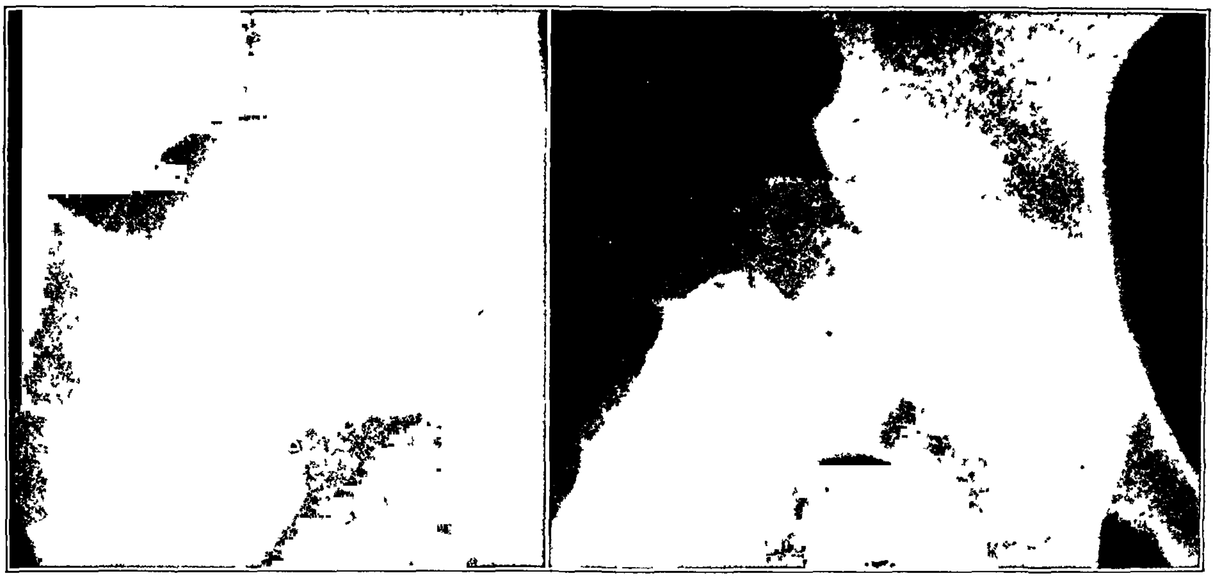

FIG. 4-J

Apr. 19, 1947 (seventeen years after onset and fifteen and one-half years after operation). The head is rounded, but lipping appears at each margin. One third of the head is outside the acetabulum.

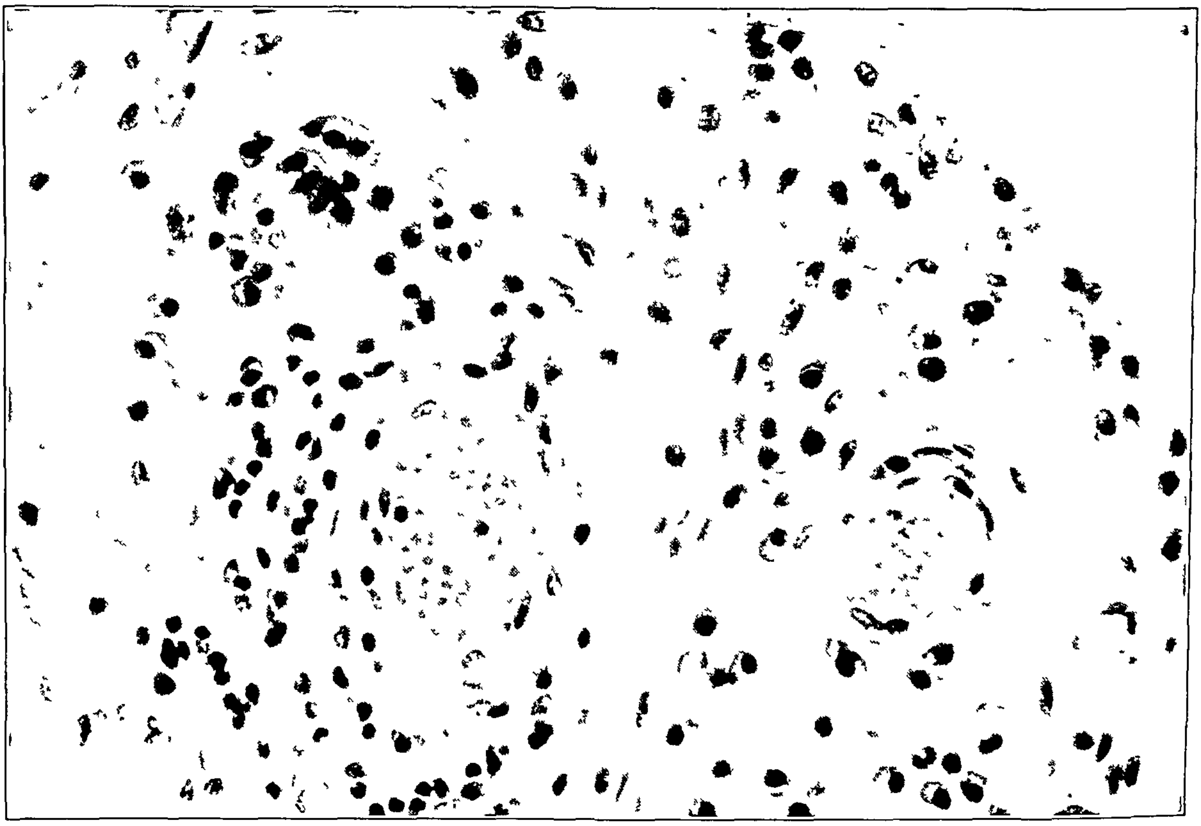

FIG. 4-K

At operation on Oct. 22, 1931, the synovial membrane showed marked oedema and hypervascularity. Villi are present. There is marked infiltration with plasma cells and lymphocytes.

tissues and healing of the bone, preventing further damage by weight-bearing and activity. It is especially important in the incipient stage, when the symptoms and signs are acute, and later, when there is a great deal of decalcification of the head. Slight flexion of the hip is preferable, in order to relax the capsule and the blood vessels about the neck. Traction for two or three weeks is desirable for the relief of pain and spasm in the acute case, but it should not be prolonged. Rest should be continued until there is no pain or spasm with motion, and until the roentgenograms show sufficient regeneration of the head for safe weight-bearing.

The best ambulatory treatment for coxa plana is a sling and crutches; this method has been used in about twenty of our cases (Figs. 2-A to 2-H, inclusive). A webbing belt with a shoulder strap, similar to the Sam Browne belt, is used for the sling which is suspended from the belt and encircles the ankle. The lower extremity is thus suspended, with the hip and knee in flexion. The hip is supported in a protected and relaxed position, and the circulation is given a chance to recover.

Fig. 5-A

Case of typical coxa plana, with early diagnosis, in a child of eleven years. Rapid healing followed *drilling, through both the neck and articular surface of the head Pain and limp had been present for ten* months; the child had been in bed for six months. Rotation was slightly limited.

Fig. 5-A: June 3, 1940. Ten months after onset, the capsule is swollen; the head is flat laterally. The joint space is wide, superiorly and medially. Slight subluxation is present.

Fig. 5-B

Dec. 2, 1940. After sixteen months, there is decalcification of the head laterally and of the neck near the epiphyseal line, with condensation of the head centrally.

The operation, performed on Dec. 5, 1940, consisted in drilling with a Nicola gouge both through the neck and through the articular surface of the head.

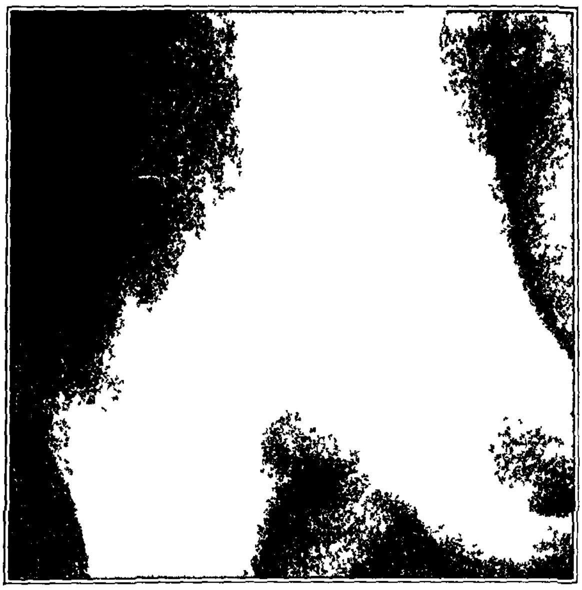

FIG. 5-C

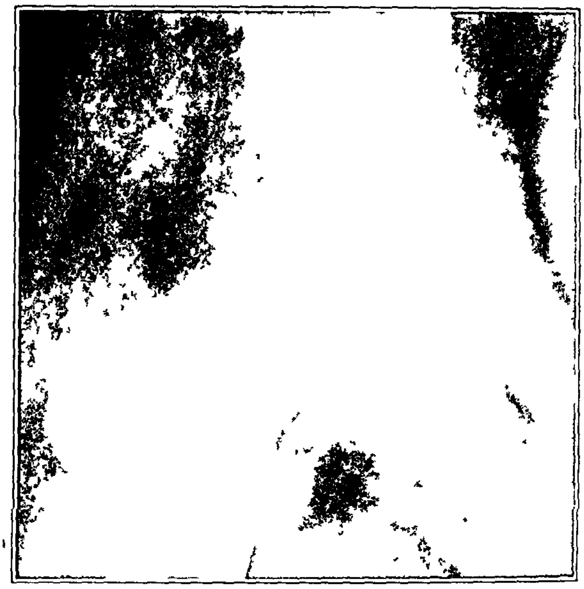

FIG. 5-D

Fig 5-C: Jan. 29, 1941 (eighteen months after onset and two months after operation). Shows more decalcification of the head laterally, more density centrally. Drill holes are visible The proximal surface of the neck is convex and is growing into the head.

Fig 5-D: Mar. 26, 1941 (twenty months after onset and four months after operation). The head is more calcified laterally, less dense centrally. The epiphyseal line has healed.

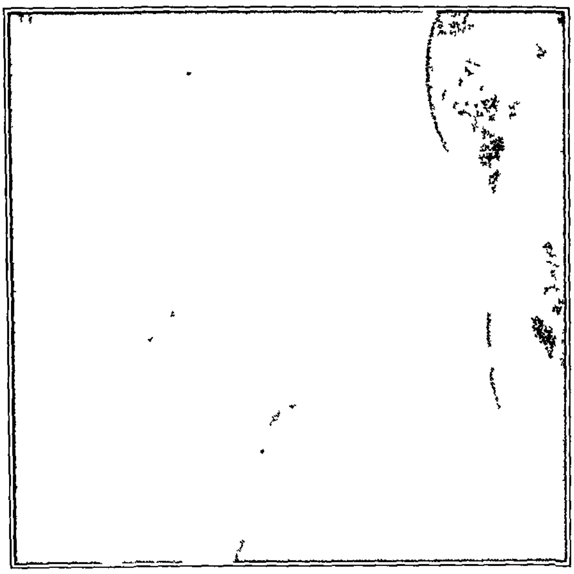

FIG. 5-E

FIG. 5-F

Fig. 5-E: May 22, 1941 (twenty-two months after onset and six months after operation). Ossification is more even.

Fig. 5-F: July 23, 1941 (twenty-four months after onset and eight months after operation). The head is almost evenly ossified. It is wide, thin, flat, and slightly subluxated.

The non-weight-bearing long leg brace with a built-up shoe for the good side may be used, but it is heavy and clumsy, more expensive, and less satisfactory than the sling and crutches; and it maintains the hip in extension instead of relaxed in flexion. Crutches alone may be used, but generally the child cannot be depended upon to keep his weight off the extremity.

Immobilization in a plaster cast or traction brace tends to increase the limitation of motion, especially if continued for weeks or months. However, a cast or a traction splint may be used for two or three weeks for the relief of acute pain and spasm.

Drilling Operation

The drilling operation has been used in approximately fifty cases at the New York

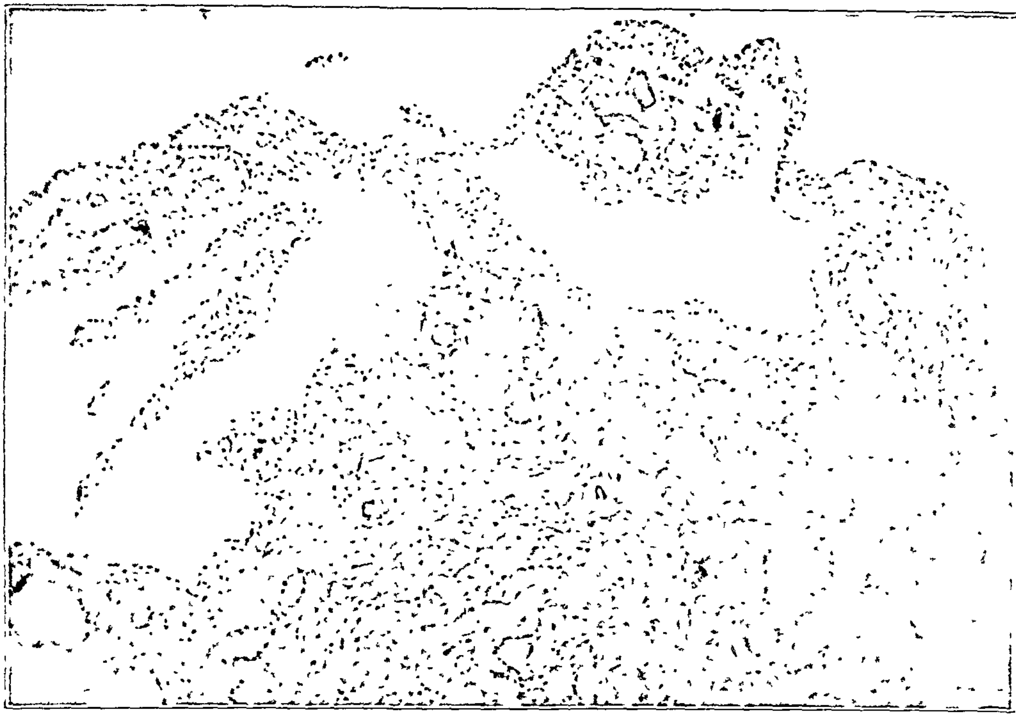

Fig. 5-G

At operation on Dec. 5, 1940, the synovial membrane showed moderate hypervascularity, hyperaemia, and villous formation. There is slight oedema. Many lymphocytes are present.

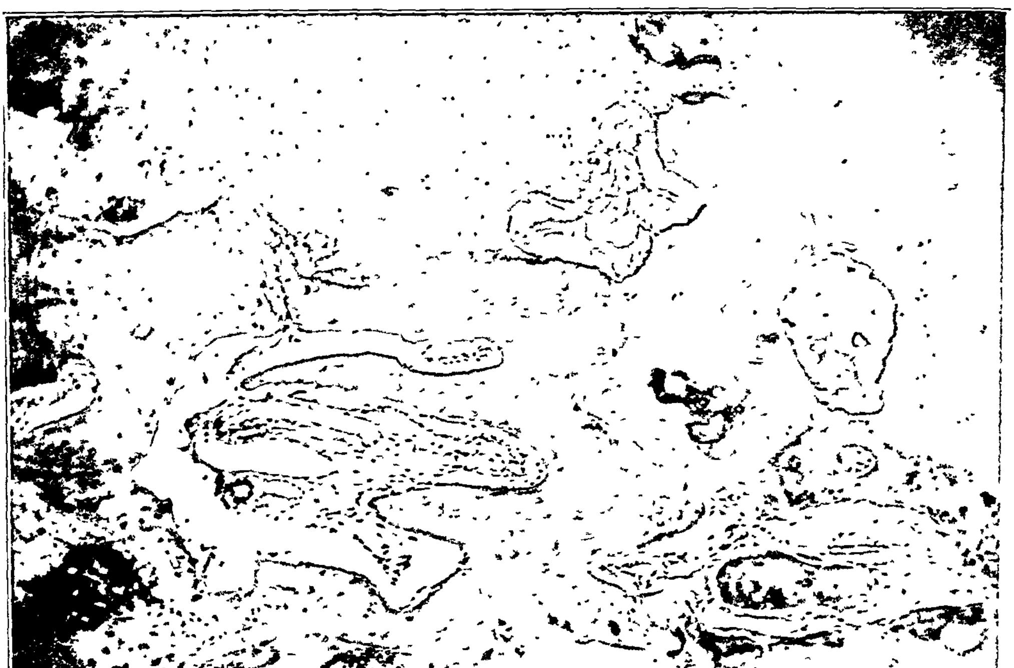

Fig. 5-H

Shows degeneration of hyaline cartilage of epiphyseal plate. Fibrocartilaginous repair is occurring at epiphyseal line. The bone trabeculae are of irregular architecture.

Orthopaedic Hospital, in the twelve years from 1928 to 1939, for hastening the healing of the disease process (Figs. 3-A to 5-H, inclusive). The hip is exposed through a short

Smith-Petersen incision, and a fenestration is made in the neck anteriorly, at the margin of the head. Three or four holes are made with an awl, a drill, or a Nicola gouge, through the epiphyseal plate into the affected area of the head. These holes are for the purpose of penetrating the diseased areas, in order to allow more rapid revascularization and recalcification. The fenestration may be filled with a small piece of muscle to stop bleeding. It is important that the operation be done gently and skillfully, with a minimum of dissection, trauma, and damage to the circulation. The drilling was done in two hips through the greater trochanter, and twice it was done directly through the articular cartilage of the head and through the head into the neck. The former approach is too uncertain, however, and the latter seems to offer no advantage, but rather the possibility of greater damage. We have not attempted to curette the head, use bone chips or pegs, or transplant a muscle flap.

An elastic-bandage spica is applied to the hip after the operation, and its use is continued for two or three weeks. Active supported motion is begun a day or two after the operation. The motion has usually returned to the preoperative range within three weeks after operation. Weight-bearing is not permitted until all pain and spasm have subsided, and the roentgenogram demonstrates sufficient bone regeneration for safe weight-bearing,—usually a year or more after the onset. Weight-bearing is begun gradually, usually with crutches.

The follow-up period after the operation has been from eight to eighteen years. The operation has been found most useful when performed in the progressive stage or in the early stage of repair. The total amount of degeneration and the residual deformity appeared to be reduced by this procedure, and the period of convalescence has been shortened about one third. No new degenerative areas appeared, and repair began promptly after the operation. In order to be most effective, the operation must be combined with a period of several months of non-weight-bearing. Better results were obtained in the group of patients operated upon than in the other groups.

SEQUENCE OF CHANGES

Early Clinical Features (from onset to one or two years):

Protective limp.

Pain, referred to groin, medial aspect of thigh, or knee.

Slight limitation of motion, with pain and spasm at extremes.

Atrophy of thigh.

Slight elevation of erythrocyte sedimentation rate.

Early Pathological Changes (from a few months to two years after onset):

Synovial membrane swollen, oedematous, vascular, villous.

Lymphocytic infiltration, especially about the blood vessels.

Scattered plasma cells and mononuclear wandering cells (histiocytes).

Degeneration of hyaline cartilage of epiphyseal plate.

Fibrocartilaginous repair at junction of plate with neck.

Irregular architecture of bony trabeculae of capital epiphysis.

Early Roentgenographic Changes:

Swelling of joint capsule (first few weeks).

Flattening or irregularity of articular surface of ossification center of capital femoral epiphysis, usually laterally, with widening of joint space superiorly (first few months). Cartilaginous head remains round.

Neck begins to widen.

Widening of epiphyseal line with decalcification at its junction with the neck.

Widening of joint space medially, due to swelling and thickening of soft tissues at Haversian gland.

Increased density of part of ossification center, usually the central portion.
Areas of diminished density in ossification center, usually medially and laterally.
Epiphyseal line begins to recalcify (second year).
Decalcification of dense area, which breaks up into bony islands of variable size and shape, surrounded by granulation tissue.
Recalcification of decalcified areas at margins of head.
Proximal surface of neck becomes convex, growing into head.
Epiphyseal line reossified and healed.
Swelling of capsule subsides.
Recalcification of central portion of head begins (third year).
Head is wide, thin, and rounded, but much flatter than normal; lateral third projects beyond acetabular margin.
Acetabulum begins to conform to shape of head (third to sixth year).
Femur short, due largely to flattening of head and shortening of neck.
Ingrowth of bone from neck into central portion of head not uncommon.
Head fills in with bone, but texture and density are uneven.

Late Clinical Features (three or more years after onset):
Limp, due to shortening and mechanical limitation.
Motions, especially abduction and rotation, slightly limited by incongruity of femoral head and acetabulum, and by contracture of capsule and ligaments.

Late Pathological Changes:
Synovial membrane thickened, avascular, and sclerotic.
Capsule thickened and contracted.

Late Roentgenographic Appearance (five or more years after onset):
Head completely filled in; texture homogeneous.
Head and neck broad; head thin and flattened, and projects beyond acetabulum about one third.
Osteochondritis, with lipping at margins of head and acetabulum.
Thinning of joint space with condensation of adjacent bone, and occasional cystic degeneration.

CONCLUSIONS

Degenerative changes, similar to those observed in coxa plana, often occur in the course of treatment of congenital dislocation of the hip, slipping of the upper femoral epiphysis, or fracture of the neck of the femur. These changes are due to interference with the circulation to the head, either by "wringing out" of the blood vessels along the neck by immobilization in full extension, often with abduction and internal rotation, or by the separation of the head from the neck by injury or during the course of treatment. These degenerative changes can be prevented by the avoidance of immobilization in a position of tension, and by not separating the head from the neck in the course of treatment. Similar degenerative changes occur in suppurative arthritis of the hip, due to the inflammatory and mechanical pressure interference with the circulation to the femoral head. This damage can be prevented or reduced by very early adequate drainage, when there is pus or fluid under tension in the hip joint.

Coxa plana runs a self-limited course over a period of years, and always heals. There is always a residual deformity: The femoral head and neck are broad, the head is flattened and shallow, and the acetabulum is somewhat flattened and shallow to correspond to the head. Treatment has little effect on the course of the disease. Reduced activity and freedom from weight-bearing result in the relief of pain and muscle spasm, with less limitation of motion, but probably have little or no effect on the course of the disease in the femoral head and neck. Bed rest is the treatment of choice in the incipient or acute and rapidly progressive phases of the disease, and the hip should be kept slightly flexed for relaxation

of the soft tissues and improvement in circulation. The best ambulatory treatment is the suspension of the extremity from a sling and belt, with the use of crutches. This should be continued while there are pain and spasm and while the head is soft.

The drilling operation, when done skillfully and gently, with a minimum of damage to the circulation, results in more rapid healing of the lesion with less deformity, but the period of healing is still much too long. Some better method of treatment should be sought.

Coxa plana may sometimes be prevented by early rest of the hip in the incipient stage, or in the stage of synovitis preceding the degenerative changes in the femoral head. More must be learned, however, of the cause and prevention of coxa plana.

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DISCUSSION

DR. A. BRUCE GILL, PHILADELPHIA, PENNSYLVANIA: Dr. Howorth has studied Legg-Perthes disease for a considerable number of years and has had an opportunity to survey the pathological changes of the condition in fifty patients who were operated upon.

I agree with the author almost entirely in his general concept of this disease and in his insistence that rest, or non-weight-bearing, is the essential factor in its treatment. The distinguishing feature is the aseptic necrosis which is first apparent in the metaphysis—that is, the upper portion of the neck adjacent to the epiphyseal plate of cartilage—and which later is evident in the femoral head. This necrosis is revealed by the increasing decalcification that is evident in the roentgenograms. The cycle of degeneration lasts for a period of from one to one and one-half years. I think this period may be shortened by early and continued treatment. The succeeding cycle of regeneration and recalcification lasts for a period of approximately two to four years, and may also be shortened by appropriate treatment.

The exact etiology is not known, but it must be some factor or condition that interferes with a normal blood supply to the metaphysis and the epiphyseal cartilage.

I do not agree with Dr. Howorth that the delayed or the irregular calcification of the head of the femur, seen frequently in congenital dislocation of the hip, is indicative of Legg-Perthes disease. These cases present a different roentgenographic appearance and run a different course. I prefer to consider them instances of the dysplasia, or delayed or defective growth, of the structures of the hip that is characteristic of congenital dislocation.

I welcome his observations on the oedema and thickening of the synovial membrane, because they offer an explanation of the lateral displacement of the head of the femur and the palpable thickening of the joint which I have so uniformly observed. I have also commented on the fact that the head of the femur returns to its normal position in the acetabulum as healing occurs.

The deformity of the head and the concomitant deformity of the acetabulum that occur in cases untreated or treated too late are due to crushing and flattening of the necrotic head and neck during the cycle of degeneration, and can be prevented by early and adequate treatment.

The essential treatment is rest, which not only prevents bearing of weight upon the soft bone, but also overcomes and prevents contraction and spasm of the pelvi-femoral muscles which thrust the head against the roof of the acetabulum. Recumbency in bed with sufficient traction to secure relaxation of the muscles is the ideal form of treatment, until recalcification of the head is sufficiently advanced to render this precaution unnecessary. When the cycle of regeneration is sufficiently advanced, bed recumbency may be replaced by ambulation on an extension brace, which prevents the bearing of weight on the affected side.

Whether the "drilling" operation will materially shorten the course of the disease, I do not know. Its proof would require careful observation of operative and control cases that are similar in the duration and the extent of the disease.

DR. M. N. SMITH-PETERSEN, BOSTON, MASSACHUSETTS: This is a characteristic Howorth presentation,—a conscientious study of results.

It is too early to draw definite conclusions; we do not know whether drilling definitely shortens the period of protective treatment, nor do we know if it diminishes the deformity. I am sure that Dr. Howorth will follow these cases and, in the course of time, give an additional report which will aid us in deciding how valuable this form of treatment may be.

(*Continued on page 756*)

EXPERIMENTAL INTERVERTEBRAL-DISC LESIONS*

BY J. ALBERT KEY, M.D., AND LEE T. FORD, M.D., ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University School of Medicine, St. Louis

The fact that lesions of the intervertebral disc frequently cause low-back pain with sciatica is now generally recognized, and one of us [4,5] has concluded that these lesions are practically the only cause of idiopathic low-back pain with or without sciatica, and that a recognition of these lesions should supplant the former diagnoses of sacro-iliac and lumbosacral strain, subluxation, or arthritis as a cause of these complaints.

Although thirteen years have passed since Mixter and Barr showed that low-back pain with sciatica could be caused by protrusion of an intervertebral disc in the lumbosacral region, and that it was possible to relieve the symptoms in many patients by surgical removal of the protruding disc material, the operation is by no means a panacea, and end-result studies on large series of patients operated upon indicate that, in some of these patients, pain and disability of varying degrees have continued after the operation [1,2,7].

Among our own patients operated upon, the failures number between 5 and 10 per cent., and about 15 per cent. of the other patients continue to have some pain and disability. In considering these results, we were not able to determine the cause of the failure in most of the patients studied or even in those operated upon again. We have been fairly well convinced that spine fusion is not the answer, and that in our hands, the results with spine fusion are no better than they are in those patients in whom the spine has not been fused. Likewise, in the patients with persistent pain after the operation for removal of a disc, spine fusion has not been successful in relieving the pain.

We know of no experimental work in which attempts have been made to produce posterior protrusions of the intervertebral discs, or to determine the results after the operative removal of a disc by the intraspinal route. Haas has shown that excision of the disc by the anterior approach may result in fusion of the bodies of the adjacent vertebrae, and Keyes and Compere, Lob, and others have shown that similar, less extensive anterior lesions of the discs cause changes similar to those noted in hypertrophic spondylitis.

In this paper a series of experiments will be reported in which an attempt has been made to answer the following questions:

1. Will removal of the nucleus pulposus and vigorous curettement of the disc space from the posterior aspect produce fusion of the adjacent vertebral bodies in a dog?
2. When a ruptured intervertebral disc is removed surgically, should the underlying disc space be curetted vigorously, gently, or not at all?
3. What is the result in the dog when a surgical defect is produced in a disc, similar to that made in a human when a ruptured disc is removed and the disc space is curetted?
4. Is it possible to produce a unilateral protrusion of an intervertebral disc in a dog by surgically weakening the annulus fibrosus on that side?
5. Is it possible to produce a lesion of the intervertebral disc by puncturing the annulus fibrosus with a needle?

MATERIAL AND METHODS

Fourteen dogs were utilized for the experiment. Under intravenous nembutal anaesthesia, and with aseptic technique, the spinous processes and laminae of the lower four or five lumbar vertebrae were exposed. In the first dogs, a total laminectomy was performed; but, after several operations, it was found possible to produce the desired lesions of the discs after removing only one-half of the spinal arch.

* Presented at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 29, 1947.

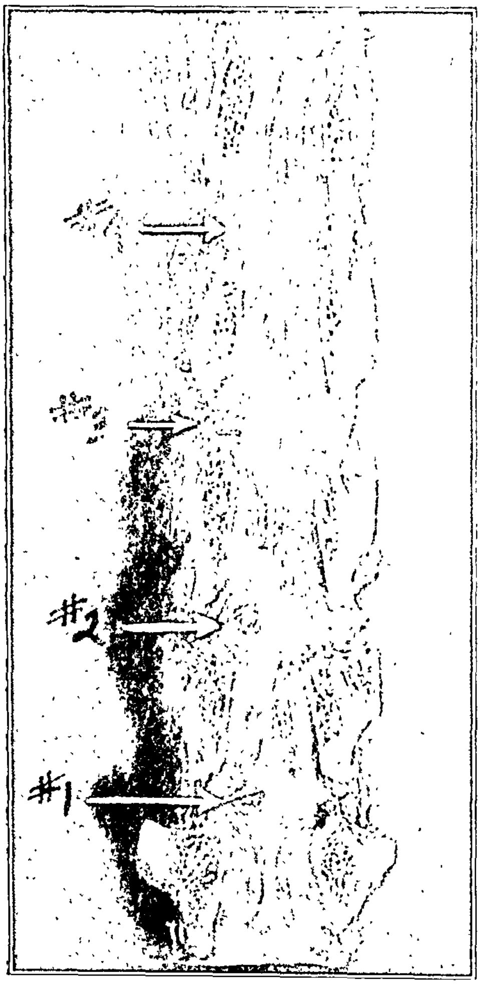

Fig. 1

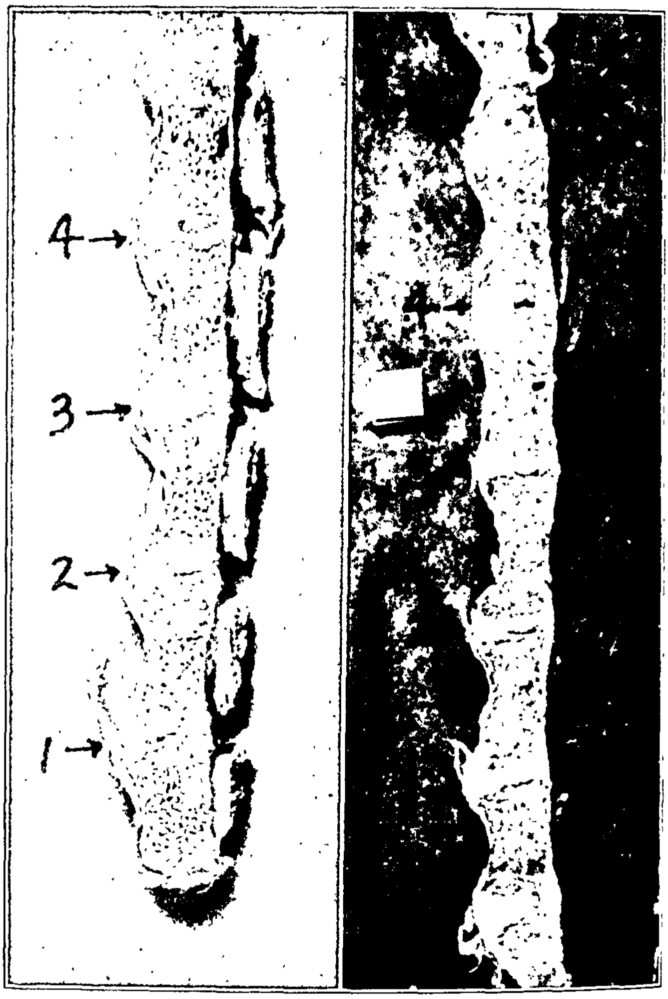

Fig. 2

Fig. 1: Dog 9. Gross specimen two days after operation, showing postoperative defects.
Fig. 2: Sagittal sections of gross specimens of Dog 9 at two days and of Dog 5 at twenty weeks, showing early collapse and late fibrosis of Discs 1 and 2.

At first, older, larger dogs were used, since it was felt that, because of the larger size of their nerve roots and cauda equina, the procedure would be simpler. However, the dense thicker bone and the firmer attachment of the soft tissue made laminectomy more difficult on these large animals, and it was found easier to work with smaller, younger dogs, weighing twelve to twenty pounds.

Routinely, four adjacent discs were exposed on the left side through the spinal canal. The epidural fat was removed with gentle suction, and the nerve root, dura, and its contents were retracted toward the opposite side. It was found that this retraction had to be done quite gently. Failure to do so resulted in paralysis of varying degrees in seven dogs. Dog 6 had a complete paraplegia and had to be sacrificed. Six dogs had a partial paralysis postoperatively. Five of these recovered completely, but one, Dog 7, with a total monoplegia, was sacrificed when it had not recovered at three and one-half weeks.

The most caudal intervertebral disc operated upon (usually the seventh lumbar) was designated Disc 1; the disc above, Disc 2; the next one above that, Disc 3; and the highest one, Disc 4. The following procedures were carried out:

Disc 1: By the use of a small tenotomy knife, a square window, including posterior longitudinal ligament and annulus fibrosus, was removed from the left side of the posterior aspect of the disc. With a small curette, the interspace on the left was vigorously curetted until it bled. The nuclear material and cartilage thus loosened were removed with the curette and with suction.

Disc 2: The procedure followed was the same as that in Disc 1, except that the spac

BONE AND BONES. FUNDAMENTALS OF BONE BIOLOGY. Joseph P. Weinmann, M.D., and Harry Sicher, M.D. St. Louis, The C. V. Mosby Company, 1947. $10.00.

This book was written by a pathologist and an anatomist, working at the School of Dentistry of the University of Illinois. They strive to remove "the peculiar existent dissociation of clinical, experimental, and pathologic endeavors on one side, and biologic thinking on the other".

Numerous working hypotheses were created by the authors to bridge the wide gaps in our knowledge of the pathology and physiology of the skeletal system. Many physicians and investigators will have a ready challenge for some of these hypotheses, and certainly many of the hypotheses will not stand the test of time. It is the authors' hope, however, that the reader will "look on the brighter side", and believe that even a false hypothesis has merit as a stimulus to future thought and research.

Part I deals with the normal structure and growth of bone and bones. Emphasis is placed upon the fact that bone is a tissue and that bones are organs. By this emphasis the authors clarify a widespread misunderstanding of one of the fundamentals of bone biology. Part I is a splendid review of our present knowledge of the histology and histogenesis of bone tissue and bones; in fact, this will be, to many readers, the most useful part of the book. The photomicrographs are particularly good.

Part II deals, in a limited manner, with the pathology of bone and bones. Numerous important entities are omitted and there is no discussion of the vast field of joint lesions. However, the authors make no claim to a comprehensive coverage of the subject of bone and joint pathology. As indicated by the title, the book is a presentation of fundamentals.

PICTORIAL HANDBOOK OF FRACTURE TREATMENT. Ed. 2. Edward L. Compere, M.D., F.A.C.S., and Sam W. Banks, M.D., F.A.C.S. Revised with the assistance of Clinton L. Compere, M.D., F.A.C.S. Chicago, The Year Book Publishers, Inc., 1947. $5.50.

A second edition of the *Pictorial Handbook of Fracture Treatment*, with revision of the text and additional illustrations, will be welcomed by all readers who wish to gain a comprehensive, although not a detailed, review of the basic principles underlying this immensely complicated subject. Few topics are so well adapted to pictorial analysis as that of fractures; and here, the authors have utilized their material admirably for setting forth what they call "the disciplines of fracture therapy". Where necessary, excellent photographic reproductions of roentgenograms have been introduced, but in the main, line drawings have been relied upon. These have been so well selected and prepared that they serve to illustrate the essential principles of the subject with outstanding clarity and simplicity. In this respect, they recall Cotton's fracture textbook, which excelled in this form of illustration.

From the title of this book, it might be suspected that the text would be subordinated to the illustrations. Fortunately, this is not the case. Without attempting to enter into discussions of disputed techniques, the authors have presented a concise description of universally accepted principles, omitting no major points. The text, like the illustrations, assumes a diagrammatic form, but it covers very satisfactorily all the more common conditions and procedures. Even a specialist, in reviewing this book, must concede that it summarizes the subject with a clarity that is often lost in more discursive texts, and yet without sacrificing any of the essential elements. In addition, the groundwork of corrective and reconstructive bone and joint surgery has been presented for the benefit of general practitioners who may not be familiar with the possibilities of more advanced treatment. Thus, cases requiring further care will be recognized and can be referred to specially qualified surgeons for whatever procedures may be required. All in all, this splendid condensation of the extensive and bewildering subject of fracture treatment into a convenient, compact, and clearly understandable handbook of 390 pages deserves unqualified approval.

FRACTURES RÉCENTES DU COL DU FÉMUR. INDICATIONS OPÉRATOIRES. ÉTUDE ANATOMIQUE. TRAITEMENT CHIRURGICAL (Recent Fractures of the Femoral Neck). Bernard Duhamel. Paris, J.-B. Baillière et Fils, 1947. 230 francs.

This book is based upon the study of 300 cases of fracture of the neck of the femur, treated at several hospitals in Paris. Statistically, the author shows that *true* cervical fractures occur more frequently in the very aged than is commonly believed. The major portion of this work is devoted to the true cervical fracture, and it is particularly in these cases that nailing is to be considered not as a method of improving function, but primarily as a means of saving life. Of a series of eighty patients operated upon between 1930 and 1940, nailing was done in 25 per cent. The total mortality, including the patients operated upon and those who were not operated upon, was 32 per cent. Of fifty-eight patients operated upon between 1940 and 1942, 46 per cent. had nailing; the total mortality (patients operated upon and not operated upon) had dropped to 28 per cent. In 1943, of forty-nine cases treated, 74 per cent. were operated upon, with a total mortality of 17 per cent. In 1944, of 22 patients, nailing was performed in all, with a mortality of 16 per cent.

The author devotes most of the remainder of his monograph to a consideration of the following factors:

1. The anatomical structure of the neck of the femur;

2. The mechanics of fracture of the neck;
3. A classification of the various types of fracture.

In his discussion of the mechanics of the femoral head, much is lost by the use of diagrams which are inadequately described. In the chapter dealing with definite treatment, the author deprecates the use of general or spinal anaesthesia. By preference, he operates after the subcutaneous injection of two cubic centimeters of "nargenol", followed by the intravenous injection of ten milligrams of pure morphine. The importance of accurate reduction is stressed, and the Leadbetter method is discarded as inadequate. The importance of lateral traction to disengage the fragments, followed by internal rotation, is emphasized.

The Whitman manoeuvre of abduction is not a method of reduction, but a means of maintaining a reduction which has already been achieved. In nailing, this manipulation is unnecessary, and the only objective is perfect reduction.

If this can be achieved, a nail of adequate length must be inserted. Since the roentgenogram cannot assuredly be exposed in a plane parallel to the axis of the neck, roentgenographic measurements will be inaccurate; and the only true gauge of the length of the nail is the length of the guide wire which should be inserted. In order to direct the nail properly, the author has devised a rectangular, parallel-edged, double guide. It would appear to the reviewer, who lacks any actual experience with its use, to be more cumbersome than the guides which are familiar to American surgeons.

Although the points of view expressed by the author of this short monograph are not new, the presentation is so eminently logical and well organized that its reading is well worth while.

CINEPLASTY. Henry H. Kessler, M.D., Ph.D. Springfield, Illinois, Charles C. Thomas, 1947. $6.75.

The over-all management of the upper-extremity amputee from the time of amputation to his rehabilitation and return to work is one of the most important problems the orthopaedic surgeon has to face. The author has realized this for many years, and his interest and experience in this field have eminently qualified him to write an authoritative treatise such as this, covering the whole field of upper-extremity amputations. That is what it is,—it is more than a treatise on cineplasty alone.

The first three chapters are devoted to general considerations, functions of the upper extremity, and mechanical prostheses. In these chapters the fundamental philosophy and understanding of arm amputations in general are adequately discussed. Cineplasty is traced in the next five chapters through its history, physiology and anatomy, surgical technique, aftercare, and prosthesis. Other interesting chapters follow, on congenital amputations, double amputations, and plastic procedures. The final chapter on rehabilitation of the arm amputee covers the important points in this field. The book is well illustrated.

The author has presented an excellent coverage of the standard Sauerbruch method of cineplasty and cineplastic prostheses for the upper extremity, essentially as it was practised here and abroad up to and including World War II. Unfortunately, some recent knowledge concerning cineplasty and its prosthesis was not available before publication of this book. The highly important work done by the Committee on Artificial Limbs of the National Research Council will supplement Dr. Kessler's work, and should be known to all who have responsibility for rehabilitation of the arm amputee.

Further understanding of fundamental muscle physiology with regard to the requirements of the cineplastic prosthesis and the development of a new and better prosthesis, now the subject of research projects of the Committee on Artificial Limbs, should be of practical value in the further use of this method. Some further refinements of the surgical principles and technique already developed will also enlarge the field of usefulness of cineplasty.

EL ENCLAVAMIENTO INTRAMEDULAR DE KÜNTSCHER. C. Gil Turner. Madrid, *Revista Española de Cirugía*, 1946.

Turner reports his experience with the intramedullary nailing of fractures at the Hospital Provincial in Madrid. This method provides perfect reduction and complete immobilization of the fragments. No rusting of the stainless-steel nail was seen. In one case the nail bent in two weeks. Each long bone presents mechanical problems because of the size and shape of the medullary cavity. The part that the medulla plays in the healing of fractures is small. The V shape of the nail produces a minimal amount of injury to the medulla, and histologically no pathological lesions are found. Changes in the blood picture after nailing are sometimes seen in children; there may be slight eosinophilia. No other changes were seen. No change in the regeneration of the bone appears to result from the presence of the nail.

The indications for nailing are: (1) in cases of fracture in which the general condition is poor and the patient should not remain in bed; (2) in non-malignant spontaneous fractures; (3) in transverse diaphyseal fractures which tend to become dislocated laterally; (4) in fractures which are reduced easily, but in which bowing cannot be prevented; (5) in fractures with a third triangular fragment; (6) in fractures with dislocation of the humeral neck; (7) in pseudarthrosis, cases of delayed union, and in corrective osteotomies; (8) in recent compound fractures.

No cases of infection were observed. Seven cases are reported in detail, and no bad results have been observed.

When used in the conditions for which it is indicated, the author feels that this is a very important addition to the treatment of fractures. This method should not be used generally, since in most cases satisfactory results will be obtained by the older methods. The older methods of osteosynthesis, however, are more dangerous than this procedure.

History of Medicine. Cecilia C. Mettler, A.B., Ed.B., A.M., Ph.D. Edited by Fred A. Mettler, A.M., M.D., Ph.D. Philadelphia, The Blakiston Company, 1947. $8.50.

This monumental volume of over 1,100 pages inevitably invites comparison with such other well-known monographs in medical history as those by Castiglioni, Cordell, Cumston, Dunglison, Garrison, Packard, Robinson, Sarton, Sigerist, and Singer; yet it differs from them all in approach and purpose. More nearly it is akin to Gordon's recently published "Romance of Medicine". Its composition occupied the last nine years of the author's life, and it was completed only a few days before her sudden and untimely death on November 27, 1943. The research necessary for its production was made possible by the Benjamin Salzer Fund. It has now been edited and prepared for publication by Dr. Fred A. Mettler, Associate Professor of Anatomy at Columbia University. It has copious indices of personal names and of subjects, and is illustrated by sixteen well-chosen portrait engravings, one at the beginning of each chapter.

This work aims to be "a correlative text arranged according to subjects"—anatomy, physiology, pharmacology, pathology, physical diagnosis, medicine, neurology, psychiatry, venereology, dermatology, pediatrics, surgery, obstetrics, gynecology, ophthalmology, otology, and rhinolaryngology—each chapter being followed by a series of selected readings, totaling several thousand references. Neurosurgery, orthopaedics, and urology are included in the chapters on pathology, neurology, pediatrics, and surgery. It seems unfortunate that these distinguished, important, and prominent specialties, which have extensive roots and sources in history, are not accorded separate consideration. The essential purpose of the work, however—namely, to demonstrate and establish the continuity of the present with the past, which constitutes true conservatism—is abundantly well fulfilled. It is a contribution of notable and outstanding value to humanistic scholarship in medicine.

Surgery of the Ambulatory Patient. Ed. 2. L. Kraeer Ferguson, A.B., M.D., F.A.C.S. With a section by Louis Kaplan, A.B., M.D., F.A.C.S. Philadelphia, J. B. Lippincott Company, 1947. $10.00.

This large volume of 932 pages deals, as the author says, with ". . . a subject much neglected in modern medicine". The desirable features of performing operations and procedures in the office, as opposed to a hospital, are pointed out. The author cautions against attempting an operation when "the diagnosis is in doubt or the extent of the lesion not definitely known", and concludes his introductory chapter with the statement: "Ambulatory surgery should be safe surgery". With this statement all should be in agreement.

The first part of the book deals with "Surgical Principles and Lesions". Equipment, anaesthesia, dressings, et cetera are discussed, and then various types of injuries and lesions are described, together with their treatment.

Part II is devoted to "Regional Surgery". The author takes up each anatomical section of the body and describes the lesion to be encountered there. One is somewhat startled at some of the lesions which the author advocates operating upon in the office. mixed tumors of the parotid, excision of thyroglossal cysts, tumors of the breast, excision and primary closure of pilonidal cysts, fistula in ano, division of the scalenus anterior, drainage of acute suppurative tenosynovitis, excision of Dupuytren's contracture, et cetera.

Part III deals essentially with fractures and dislocations. This is a clear and complete exposition of the non-operative treatment.

The volume is an encyclopedia of the diagnosis and treatment of the less severe surgical conditions The chief criticism should be leveled at the emphasis placed upon what operations *can* be performed in the office rather than on what *should* be. If the book does not excite the inexperienced practitioner to attempt more than he is able to accomplish, it will prove of great value.

Physical Medicine in General Practice. Ed. 2. William Bierman, M D. With a chapter by Sidney Licht, M.D. New York, Paul B. Hoeber, Inc., 1947. $8.00.

This can, in general, be recommended as an adequate textbook of physical medicine. Details of technique, particularly in the field of electrotherapy, are covered sufficiently for the physiotherapist and specialist in physical medicine. In the attempt to describe practically all procedures which might be used, there results for the general practitioner possible confusion as to optimum methods. The author frequently refers to the literature and leaves the reader without information concerning the usefulness of the measures,—for example, diathermy for chronic inflammation of the liver, gall bladder, and for peptic ulcer.

The fine line drawings add immeasurably to the value of the book, particularly in relation to performance of exercises. In this second edition the most significant alteration is the inclusion of a chapter by Sidney Licht, M.D., on medical rehabilitation, which is now recognized as an important part of physical medicine. In future editions, it would be well to amplify this section of the book still further. Other deficiencies which might be pointed out in view of future revisions are inadequate description of electrodiagnostic methods, including determination of strength-duration curves, tetanus ratios, electromyography, and the use of other recently available electronic equipment. Progressive-resistance exercises appear to have enough widespread acceptance to be included in the textbook. The section on rheumatoid arthritis seems too brief, considering the importance of physiotherapy in the treatment of this disease. The same also applies to infantile cerebral palsy. The specialist in physical medicine would also like to have amplification of diagnostic procedures in this field, including techniques of mensuration of strength, joint range, manual skill, fitness, and circulatory function.

This field is expanding so rapidly that it is hoped that revisions of this excellent text will be frequent.

La equinococosis osea (Osseous Echinococcus Infestation). Hebert Cagnoli. Montevideo, Casa Impresora "La Industrial", 1947.

In this monograph Dr. Cagnoli, of the Traumatological Institute in Montevideo, reviews the literature and reports his personal experience in the treatment of echinococcus cysts of the bone. The embryos are carried from the intestinal tract to the bone by way of the blood stream. Bone infestation is rare, because the portal and the pulmonary slowing of the blood stream sift out most of the embryos. One rarely finds hydatid cysts elsewhere, when they are present in the bone. The bones most frequently affected are the vertebrae (40 to 50 per cent.), the femoral head, the humerus, the tibia, and the femur. At first the cyst is unilocular. The changes which it produces in the bone are the result of two factors, mechanical and toxic. There is no reaction on the part of the affected bone, and the osseous morphology is usually maintained. Two distinct syndromes appear, depending upon the localization of the cyst, the diaphyseal syndrome which often results in spontaneous fractures, and the epiphyseal syndrome which often produces articular symptoms. If the cyst is adjacent to bone or breaks through the bone, it may form a pseudo-abscess or multiple or solitary hydatid cysts.

The complications which arise are fracture, secondary fistulization, and invasion of the adjacent soft parts. The evolution of the lesion is very slow, but steadily progressive. Symptoms often appear late, since there are no inflammatory phenomena. There may be pain, a tumor, a fracture, muscle spasm, or fluid in a joint. There is no general reaction; the parasite is symbiotic with its host.

In the diagnosis, the roentgenogram is of most value. Biological tests, such as the reaction of Casoni and the complement deviation, are of insufficient accuracy to confirm the diagnosis. Eosinophilia of considerable degree is usually present. The roentgenogram shows an invasive lesion, with no bone reaction. There are small confluent zones of areolar osteolysis, limited by dense trabeculae. The prognosis depends upon the location, progression, and degree of evolution of the lesion. Treatment, to be effective, must be early, and consists of radical surgery. Local resection may be done if the condition is seen very early. Complete resection of a bone may be required. In the vertebrae, in which treatment must be limited to curettage, a cure frequently is not effected. Where surgery cannot be carried out, biological treatment should be tried, using the echinococcus embryo after the technique of Caleagno. Little can be expected from such treatment, however. The mortality from this disease is always 50 per cent. or higher. In cases with spinal and pelvic localization, the prognosis is particularly grave.

The American Illustrated Medical Dictionary. Ed. 21. W. A. Newman Dorland, A.M., M.D., F.A.C.S. With the collaboration of E. C. L. Miller, M.D. Philadelphia, W. B. Saunders Company, 1947. $8.50

The revision of a medical dictionary is never an easy task; at the present time it must be an especially formidable undertaking. During the years since the last edition of this authoritative work was published there have been many additions to medical terminology, resulting from the research of the war years and the countless new discoveries of this period. The compilation of a comprehensive dictionary must not only include the new terms which have crept into a well-rounded medical vocabulary, with their accurate definitions, but must also eliminate the obsolete and those no longer considered in good usage.

Those who are accustomed to depend upon this dictionary will be grateful for the new edition. It includes a number of new colored plates, some of which are excellent. Two deserving of special mention are the plate of the anterior pituitary hormones and that of the life cycle and comparative morphology of the malarial parasites of man.

The publishers may well be proud of this latest addition to their long series of medical dictionaries and related publications.

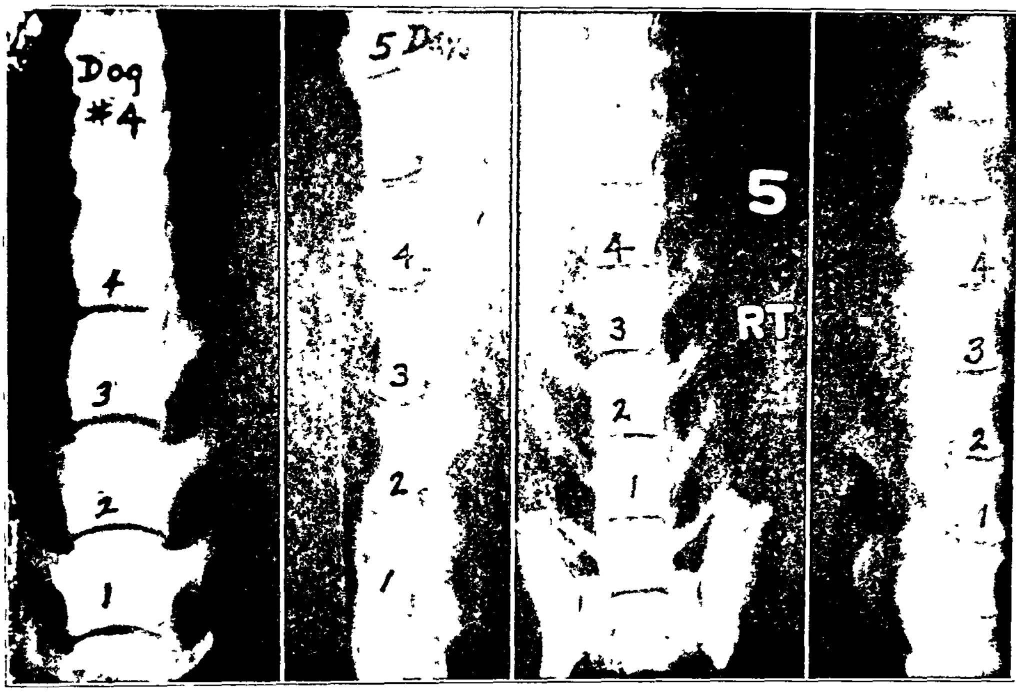

FIG. 3

Roentgenograms of Dog 4 (left) at five days and Dog 5 (right) at twenty weeks, showing that collapse of disc occurs early and does not progress, and that ankylosis does not occur in spite of injury to artilage plate, as seen in Disc 1.

\. s curetted gently, and no attempt was made to break through the cartilage plates of the rtebrae.

Disc 3: With the tenotomy knife, an incision was made transversely in the posterior ıgitudinal ligament and annulus fibrosus on the left side. Some nucleus pulposus material xuded, but the disc was not curetted.

Disc 4: A 20-gauge needle was pushed through the annulus fibrosus into the interior f the disc.

All wounds were closed with interrupted sutures of black silk. Of the fourteen dogs operated upon, wound infections developed in two; one of them, Dog 3, died and the other, Dog 6, which also had paraplegia, was sacrificed. In neither instance did the infection involve the discs operated upon. Dog 1 died of distemper at seventeen weeks; two animals, Dogs 9 and 4, died of pneumonia two and five days, respectively, after operation. Dog 7 was sacrificed at three and one-half weeks, after failure to recover from paralysis. The remaining dogs were sacrificed so that spines were obtained from the series of dogs at rvals varying from two days to twenty-eight weeks after the operation had been done. on sacrifice or death of each dog, the lumbar portion of the spine was removed, and teroposterior and lateral roentgenograms were made. The spine was then dissected from e posterior aspect. The condition of the spinal canal was noted, and each of the four discs, e nerve roots, and the dura and its contents were inspected. The spine then fixed in rmalin, after which it was split sagittally. The right half of the spine was retained as a gross specimen, and the left half of each of the four discs operated upon, with the adjacent bone, was removed and decalcified for microscopic study.

OBSERVATIONS

Macroscopic Changes

In each Disc 1 (window made and vigorous curettage) except o , and in each Disc 2

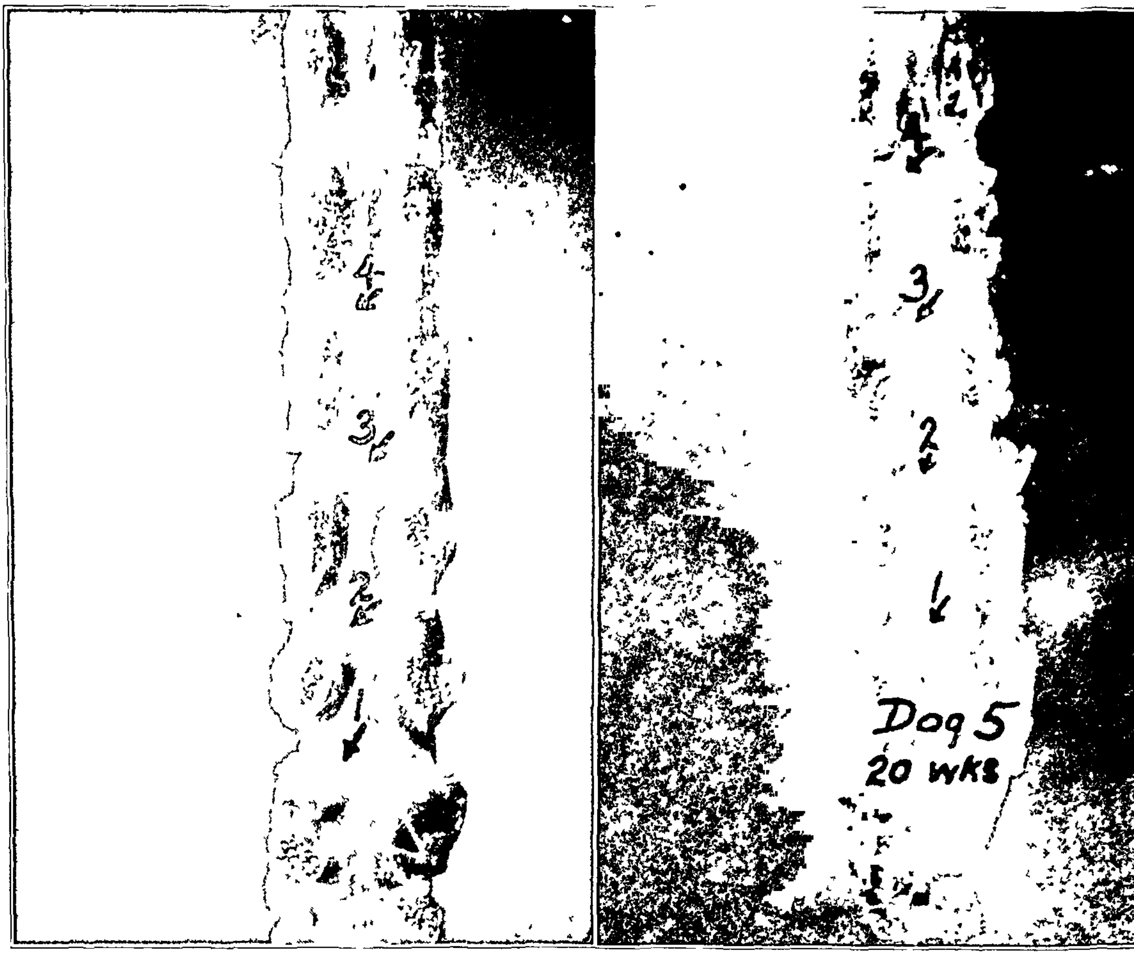

FIG. 4

Gross specimens. Dog 8 at twenty-two weeks exhibited protrusions at all four discs, and Dog 5 at twenty weeks exhibited protrusions at Discs 2 and 3 and scar formation at Discs 1 and 2. Spine viewed posteriorly, with laminae removed.

(window made and gentle curettage), collapse of the disc and narrowing of the disc space were visible in the roentgenograms and in the sagittal sections of the gross specimen. In the latter, the soft bulging nucleus was not present; in the older experiments the nucleus was replaced by fibrous tissue. The adjacent nerve roots were adherent to the discs operated upon in every instance, and these adhesions were more dense in the experiments of longer duration. In six of these roentgenograms, damage to the bone by the curette was visible at Disc 1.

Moderate protrusion of the disc substance at the site of the operative defect was present in three of the first and four of the second discs, and slight protrusion was present in four of the first and four of the second discs. In the longer experiments, these protrusions were firm and resembled some of the disc protrusions seen in patients at operation. In the remaining thirteen first and second discs of this group, the defect in the annulus fibrosus was obliterated by fibrin or fibrous tissue, and the site of the operative defect was level with or depressed into the disc space.

In the third discs, the annulus fibrosus in the floor of the spinal canal had been cut across with a tenotomy knife for a distance of about one-half the width of the canal, and some nucleus pulposus substance was seen to have exuded through the incision in each instance. In the gross specimens it was noted that the incision was closed by fibrin in the dogs sacrificed very early, and by fibrous tissue in those in which the experiment had lasted long enough for this tissue to form. In nine of the fourteen specimens the adjacent nerve root was adherent to the third disc, but the adhesions were not so dense or extensive as were those which bound the nerve roots to Discs 1 and 2 in the same specimens. The scar of the

incision was visible as an interruption of the vertical fibers of the annulus fibrosus and the posterior longitudinal ligament.

In four of the later specimens of the series (dogs sacrificed at twenty, twenty-one, twenty-two, and twenty-eight weeks), Disc 3 exhibited a well-developed rupture and a

FIG. 5-A FIG. 5-B

Early surface healing of Disc 2 of Dog 3 at five and one-half weeks (Fig. 5-A) and of Disc 1 of Dog 14 at eight weeks (Fig. 5-B). Disc cartilage and debris in disc cavity of Dog 14.

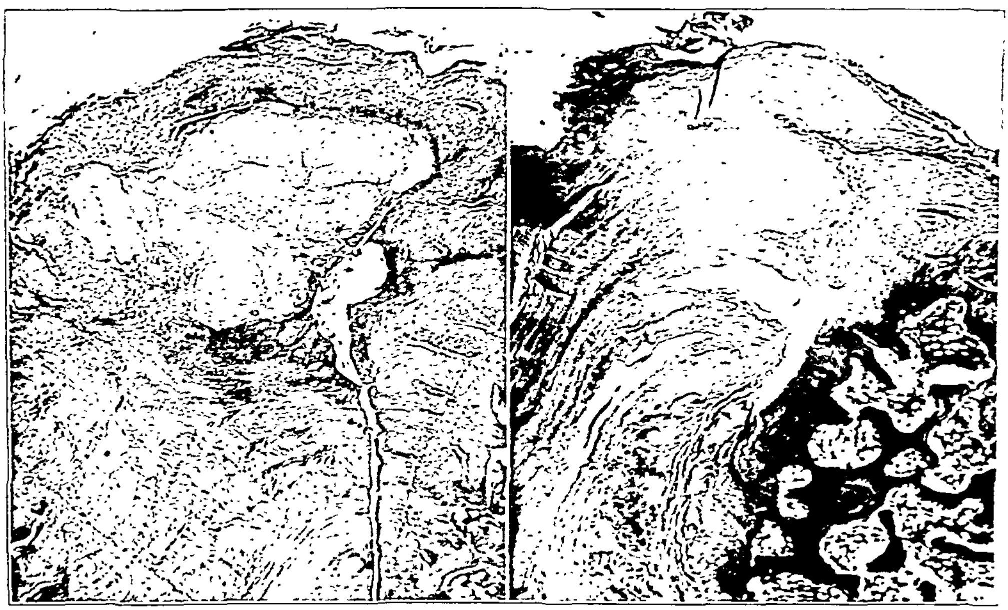

FIG. 6-A FIG. 6-B

Surface healing in Disc 2 of Dog 14 at eight weeks (Fig. 6-A) and of Dog 13 at fifteen weeks (Fig. 6-B), with failure of deeper layers of the annulus fibrosus to heal and with disc cartilage displaced beneath the thin surface layer. The fifteen-week specimen showed a moderate disc protrusion.

FIG. 7-A FIG. 7-B

Typical disc protrusion at Disc 3 of Dog 5 at twenty weeks (Fig. 7-A), and moderate protrusion of Disc 3 of Dog 2 at twenty-eight weeks (Fig 7-B).

protrusion of the nucleus pulposus. These were firm, smooth, domelike projections and closely resembled disc lesions encountered in patients at operation for the removal of protruding intervertebral discs. In five other specimens (dogs sacrificed at twelve, three and one-half, eight, fifteen, and sixteen weeks), slight protrusion of the intervertebral disc was present at the site of the incision in the annulus fibrosus. There was moderate collapse of the disc, with narrowing of the intervertebral space of Disc 3 in two dogs and slight collapse of the disc and narrowing of the space in six dogs.

Six of the specimens of Disc 4, which had been punctured once by a 20-gauge needle, appeared normal on gross examination. In eight, the site of the puncture could be identified as a minute scar; and in three of these, there were slight adhesions between the posterior surface of the disc and the adjacent nerve root. In one instance (dog sacrificed at twenty-two weeks), Disc 4 exhibited a small but definite and characteristic posterior herniation and protrusion of the nucleus pulposus at the site of the needle puncture. The adjacent nerve root was slightly adherent to this disc protrusion, and there was slight collapse of this disc with narrowing of the intervertebral space. In the other thirteen specimens, there was no definite collapse or narrowing at Disc 4.

In all fourteen specimens, the dura was adherent to the muscle and fibrous tissue which closed the laminectomy defect, and in the dogs sacrificed later these adhesions were quite dense, but they did not appear to compress the intradural contents or the adjacent nerve roots. As was noted previously, there were in most instances adhesions between the operative site in the disc and the anterior surface of the dura and the adjacent nerve roots, but the lateral epidural space was filled with epidural fat.

In one instance (dog sacrificed at sixteen weeks), a small cotton pledget was found overlying the site of operation in Disc 1. This was infiltrated with fibrous tissue and was bound to the adjacent structures, but apparently it had not done any harm or produced any symptoms. In some of the older specimens, there was some new-bone formation posteriorly, with beginning regeneration of the laminae, but in no instance was there any evidence of bony fusion of the bodies of the vertebrae.

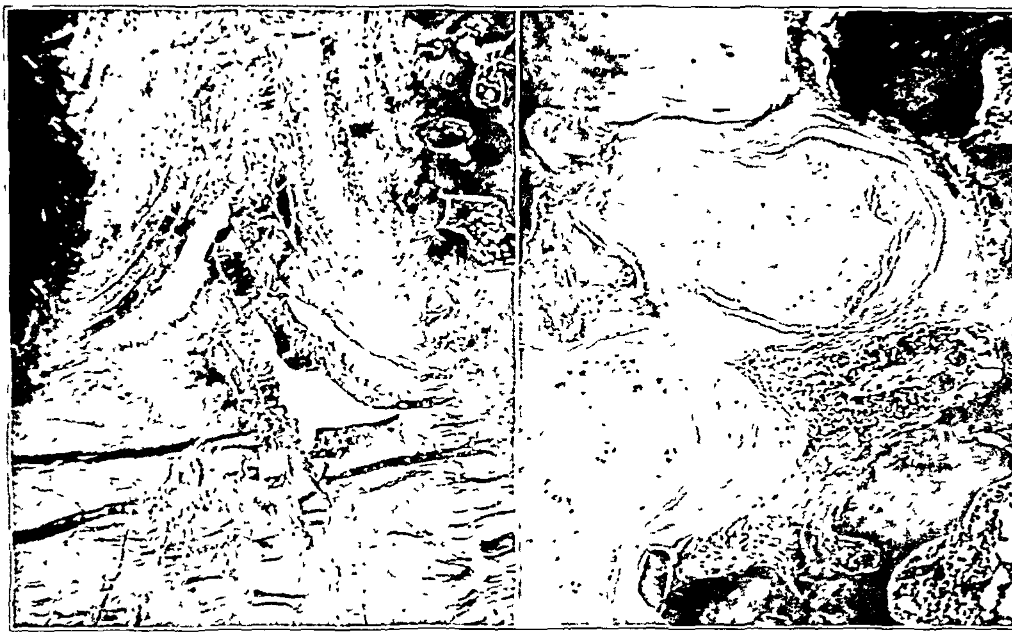

FIG. 8-A FIG. 8-B

Fibrosis of central part of Disc 1 of Dog 2 at twenty-eight weeks (Fig. 8-A), and cartilage invasion of the bone through defect created by curette in cartilage plate of Disc 1 of Dog 14 at eight weeks (Fig. 8-B).

Microscopic Observations

In the specimens of Disc 1 from dogs which died on the second and fifth days after operation, the operative defect was sealed over with fibrin and the disc space contained some extravasated blood, bone, cartilage debris, and fibrin. In the later specimens, the operative defect was sealed by a layer of fibrous tissue, which was relatively thin, as compared with the annulus fibrosus, and the density of which increased, the longer the duration of the experiment. In those instances where the microscopic section was taken through a disc protrusion, the layer of fibrous tissue covering the disc was unusually thin and bulged outward from the disc cavity with the displaced cartilage tissue of the nucleus pulposus.

Microscopic sections of the interior of Disc 1 showed a fluid which contained a thin fibrin coagulum. In this were suspended various islets or masses of cartilage from the nucleus pulposus, as well as occasional bits of bone and hyaline cartilage, which had been detached from the bodies of the adjacent vertebrae by the vigorous curetting. The surface layers of these masses of cartilage from the nucleus pulposus were granular in structure and stained deeply with eosin; they contained no living cells, and appeared necrotic. The fluid in the disc cavity contained very few cells of any sort, except for degenerating blood cells where the experiments were of short duration. The detritus from the operative trauma had, apparently, disappeared quite slowly from the disc space. In the longer experiments there was considerable fibrosis of the disc substance (Fig. 8-A), or at least thickening of the annulus fibrosus in the area not involved in the operative defect, and there was some invasion of the underlying bone by cartilage in areas where the curette had broken through the cartilaginous plate of the vertebra (Fig. 8-B). These areas resembled microscopic Schmorl's nodes.

The microscopic sections of Discs 2 and 3 exhibited changes similar to those of Disc 1, as described before, except that the cartilaginous plates of the vertebrae were intact and no bone fragments were found in the disc space. The protrusions were similar to those described; in some of these, a channel could be traced down to the interior of the disc (Fig.

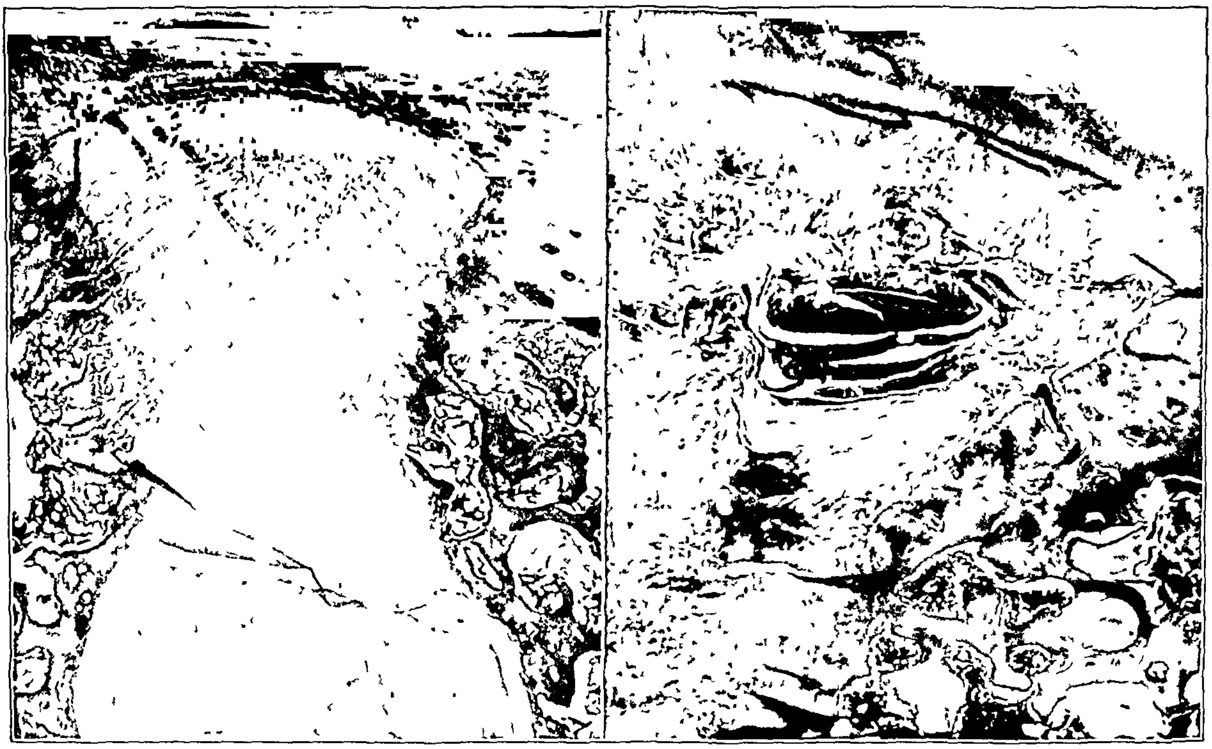

FIG. 9-A FIG. 9-B

Approximately normal Disc 4 of Dog 14 at eight weeks (Fig. 9-A), and protrusion of Disc 4 of Dog 8 at twenty-two weeks (Fig. 9-B), with minute islets of cartilage distributed through the disorganized fibrous tissue of the annulus fibrosus.

7-A), and this apparently had contained fluid. In others, the protruding cartilage was subdivided into two or more masses by fibrous tissue.

It was noted that the annulus fibrosus had a very poor blood supply, and that the defects in the annulus fibrosus tended to heal at the surface, while the operative defect in the deeper layers tended to remain open for a long time (Figs. 6-A and 6-B).

With the exception of Dog 8, sacrificed after twenty-two weeks, sections of Disc 4 which were examined (Fig. 9-A) revealed nothing abnormal, and the site of the needle puncture could not be identified. In Dog 8, Disc 4 showed disorganization of the annulus fibrosus and a protruding disc with minute islets of cartilage scattered throughout the fibrous tissue (Fig. 9-B).

DISCUSSION

The experiments were performed by operating through the spinal canal in much the same manner as the operations on patients for the removal of disc protrusions, and it is believed that the experimental lesions are comparable to those produced by operations on patients. In none of the experiments was bony ankylosis produced between the bodies of the vertebrae. Consequently, it is doubtful that it is practical to curette the disc space sufficiently at operation to expect bony fusion to occur. To do so would involve excessive traction on and trauma to the adjacent nerve root, and would not be good surgery.

In the experiments, the collapse of the vertebrae, with narrowing of the disc space, occurred promptly after the operation and was not seen to progress throughout the duration of these experiments (Fig. 2). The production of posterior protrusions of the nucleus pulposus, on the other hand, appeared to be a slowly progressive phenomenon. The earliest well-developed protrusion was noted in a specimen removed twenty weeks after the operation. Apparently the surface of the defect heals over with a thin layer of fibrous tissue, while the deeper part of the defect remains unhealed and in communication with the cavity in the disc. This cavity is filled with fluid which is under pressure and which causes

bulging of the thin surface tissue; some of the freely floating disc cartilage is displaced into the protrusion and becomes fixed there.

The protrusions were more prominent and slightly more numerous in the third discs, which were merely incised and not curetted, than they were in the first or second discs, which were curetted. However, it did not seem to make much difference whether the curetting was gentle or vigorous, since the postoperative protrusion formation was about the same in each instance. It is possible that the protrusions would occur more frequently in an upright animal, where the pressure within the disc is greater, but the muscle tone and movement in the dog are evidently sufficient to cause typical protrusions of the nucleus pulposus into the spinal canal, if the posterior portion of the annulus fibrosus is weakened by a surgical incision which is permitted to heal.

In the fourteen discs (all Disc 4) which were punctured once (not aspirated) by a 20-gauge needle, a typical protrusion occurred in one instance. This indicates that this same phenomenon may occur in patients—as reported by Pease and others—and that a complicating infection may not be necessary for the production of a pathological disc lesion after injury to the disc during a lumbar puncture.

After operation on Discs 1 and 2, the constant presence of adhesions which involved the adjacent nerve roots was especially impressive, and they are a possible cause of symptoms in patients in whom the spinal canal has been explored after an unsuccessful disc operation.

The authors believe that during disc operations the nerve roots should be protected from trauma in every way possible. The disc space should be gently, but thoroughly, curetted, without any attempt to break through the cartilaginous plates of the vertebrae; and everything possible should be done to prevent postoperative adhesions involving the nerve roots.

The experiments suggest that the primary lesion which leads to a protrusion of an intervertebral disc is a weakening of the posterior portion of the annulus fibrosus. This may be due to degenerative changes or to injury. The degenerative changes in the nucleus pulposus appear to be secondary, as suggested by Eckert and Decker.

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DISCUSSION

Dr. Edward L. Compere, Chicago, Illinois: We are indeed indebted to Dr. Key and Dr. Ford for this excellent experimental study, in which they have answered to a considerable degree some of the many problems which have puzzled all of us who have had occasion to deal clinically with the problem of the inter-

vertebral disc. One should perhaps mention the fact that in laboratory animals, such as the dog, the nucleus pulposus is much more fluid than it is in the human, with the exception of the infant. Slight injuries to the annulus fibrosus would be more likely to produce extravasation of the gelatinous fluid in the dog than in the adult human, in whom the nucleus pulposus is pulpy and not fluid.

Also, as mentioned by the essayists, in the dog the pressures exerted on the intervertebral disc before and after injury are those produced by the muscles, and are not so great as in animals in which the spine is vertical most of the time.

About ten years ago, Dr. Donald Keyes and I carried out similar experiments on the monkey. The monkey does assume the upright position. Upon injury to the annulus fibrosus, there was almost immediate collapse of the disc space. This would not occur in the human being, because of the difference in the nature of the content of the disc. In the human, the pulpy material would be expressed over a long period of time after the injury.

In all of the monkeys, arthritic changes developed on the margins of the vertebrae, following loss of the disc material. The intervertebral disc is an important structure, essential to the normal physiology of the spine. It is the shock absorber between the vertebral bodies, and it keeps them from striking against and eroding each other. When the disc is lost as a result of surgical removal or of intervertebral injuries, backache may persist for months or years, unless the spine is stabilized.

I am pleased to note that vigorous curettement of the disc has been condemned by Dr. Key and Dr. Ford on the basis of their experimental results.

I am not willing to accept the reports of several neurosurgeons that they were able to fuse the vertebral bodies by simply curetting the disc space. In reviewing my cases over a period of ten years, I have not found one in which there was demonstrable evidence of fusion between the vertebral bodies after disc removal. The same was true in our experiments in which monkeys were used. About eight months ago, Dr. Paul Milligan, one of our orthopaedic residents, began a series of experiments with dogs. He removed the discs through the spinal canal. In one group of animals, the spine was not supported. In a second group, he performed an interlaminal fusion. The animals have not been sacrificed, but it is our impression from study of the roentgenograms that there are less degenerative changes in the spines of those dogs in which the laminae were fused. In none of the dogs where the disc was merely curetted has fusion taken place.

Dr. Lee T. Ford (closing): I wish to thank Dr. Compere for his kind remarks.

The reason we have not done a fusion operation in our cases is because of clinical experience, not because of experimental work. Dr. Key has, in the past, combined the disc operation with spine fusion, but has not been satisfied that the result is more satisfactory than that obtained by merely removing the offending disc.

DISCUSSION

Bone and Joint Changes in Hemophilia

(Continued from page 600)

layed coagulation time being unknown, the treatment is non-specific and unsatisfactory. It is the opinion of most research workers that the cause is a decreased amount of plasma thromboplastin, and it is hoped that further investigation may develop some purified form of thromboplastin which will be of real help. In the meantime, one must resort to the application of fresh blood or plasma and pressure to superficial cuts and lacerations; transfusions of blood, thirty to forty cubic centimeters every few hours, should be administered until early healing has been accomplished. In cases of emergency, operations may be undertaken if small quantities of blood can be administered several times before operation and continued through the healing period after operation. These measures may suffice for procedures which involve little cutting of deep tissues, but those which involve section of the bones or extensive severance of muscles may result in uncontrollable bleeding. When the factor of infection and tissue sloughing is introduced, the problem is so greatly complicated that most patients do not survive.

I am unable from my own experience to comment on cases of pseudotumor, as described by the authors. I have treated two adolescent boys who had contractures of the knee after repeated intra-articular hemorrhages. Both patients had resorted to the use of crutches, because of inability to straighten the knee. In both cases the condition was corrected rather easily by gradual stretching in plaster; the patients subsequently used braces for several months, regained, for the time being, useful ranges of motion, and were able to walk without crutches.

ASEPTIC NECROSIS IN GAUCHER'S DISEASE

BY ALVIN M. ARKIN, M.D., AND ALBERT J. SCHEIN, M.D., NEW YORK, N. Y.

From the Mount Sinai Hospital, New York City*

In a previous paper, the authors described and attempted to classify hip-joint changes in Gaucher's disease. Apart from the statement that changes in the femoral head in children resemble those of Legg-Perthes disease, and that the ultimate changes in the hip joint in adults might be of degenerative origin and might be secondary to these childhood lesions, no attempt was made to interpret the pathological-physiological background for these changes. Subsequently, in the one patient treated by prolonged relief from weight-bearing, almost complete restitution of the femoral head took place. At about the same time, cases of Gaucher's disease in adults were encountered, which markedly resembled cases of caisson disease, at least with regard to the bone changes. In addition, in one of our adult cases, roentgenograms taken during childhood indicated that the condition actually had begun, as we had hypothesized, in childhood as a Legg-Perthes-like condition.

These facts strongly suggest that one of the determining factors in the occurrence of hip-joint manifestations in Gaucher's disease is the presence at some time, in childhood or adult life, of aseptic necrosis in the femoral head. Phemister discussed the known and unknown causes of such changes. Although he included the lesions of traumatic origin, such as fractures and dislocations involving the known blood supply of the injured parts, and the non-traumatic lesions, such as caisson disease, arteriosclerosis, osteochondritis dissecans of the hip in adults, and Legg-Perthes disease and the other osteochondroses of childhood, he did not include Gaucher's disease. He did mention that he had seen collapse of the femoral head with osteo-arthritis of the hip in Gaucher's disease, which resembled idiopathic osteochondritis dissecans of the hip in adults.

This paper is presented for the purpose of drawing together these various observations, as they are related to the occurrence of a pattern which suggests that aseptic necrosis of bone is a significant factor in Gaucher's disease of bone.

FIG. 1-A

December 1939. Early changes simulating Legg-Perthes disease.

* Orthopaedic Service of R. K. Lippmann, M.D.

CASE 1 (Case 1 in the previous paper). M. D., a German-Jewish girl, was ten years of age when admitted to the Mount Sinai Hospital on October 18, 1939. The diagnosis of Gaucher's disease was made, and was confirmed by sternal-bone-marrow puncture. Roentgenograms showed clubbing of the lower ends of both femora. The left hip showed early femoral-head changes, resembling Legg-Perthes disease (Figs. 1-A and 1-B).

FIG. 1-B
May 9, 1940. Further necrotic changes in the femoral head.

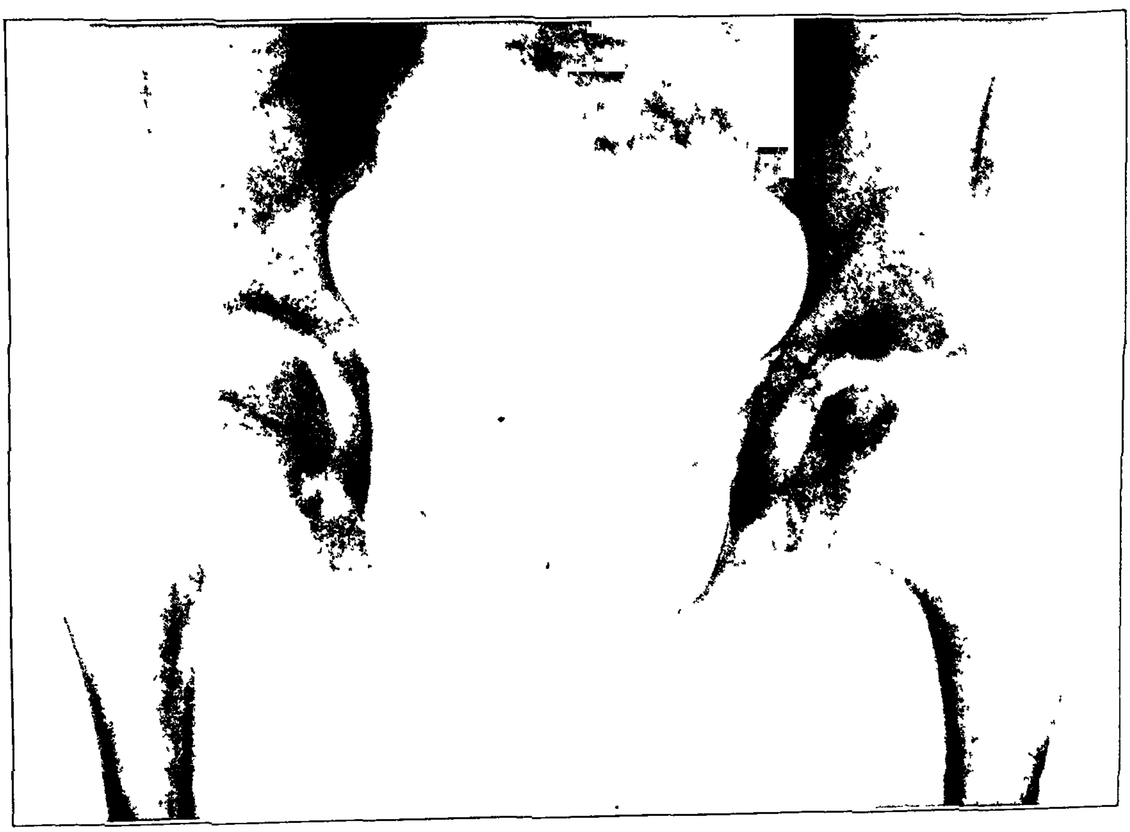

Fig. 1-C
September 14, 1941. Early regeneration of capital epiphysis.

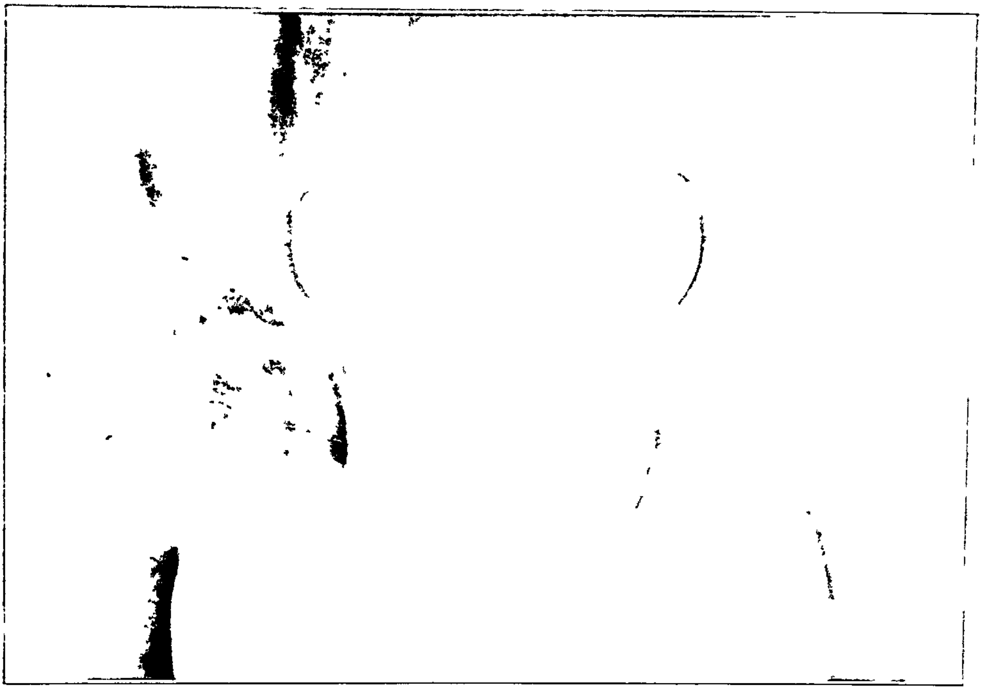

FIG. 1-D

February 1943. Only a small area of increased density remains in the center of the femoral head.

FIG. 1-E

January 1944. Apparent reconstitution of the head, resembling healed Legg-Perthes disease

She improved rapidly, both clinically and by roentgenogram, with bed rest. Roentgenographic examination in September 1941 showed definite, though partial, reconstitution of the structure of the head (Fig. 1-C). On October 22, 1942, reconstruction of the head, as checked by serial roentgenograms, had proceeded so far that gradual resumption of weight-bearing was allowed.

The patient was again seen early in 1943 (Fig. 1-D). She walked well, without pain. The angle of greatest

flexion was 80 degrees; the angle of greatest extension was 180 degrees; external rotation was 0 degrees, internal rotation 25 degrees; abduction was 10 degrees, adduction 25 degrees.

The girl returned to school on May 25, 1944. Her last examination, on July 27, 1944, revealed that the angle of greatest flexion had increased to 65 degrees. There was slight restriction of abduction and rotation.

This is the only case report the authors could find in which reconstitution to a state approximating normal, roentgenographically and clinically, occurred in a case of Gaucher's disease, involving the femoral head and hip joint, while the patient was under observation. Presumably, this fortunate outcome was due, as is true in Legg-Perthes disease, to protec-

FIG. 2-A

September 29, 1925. Infiltration into both femoral heads during adolescence. Legg-Perthes-like changes in the left femoral head.

FIG. 2-B

June 7, 1929. Healed stage, showing flattened mushroomed heads which resemble the healed stage of Legg-Perthes disease when the heads have not been protected.

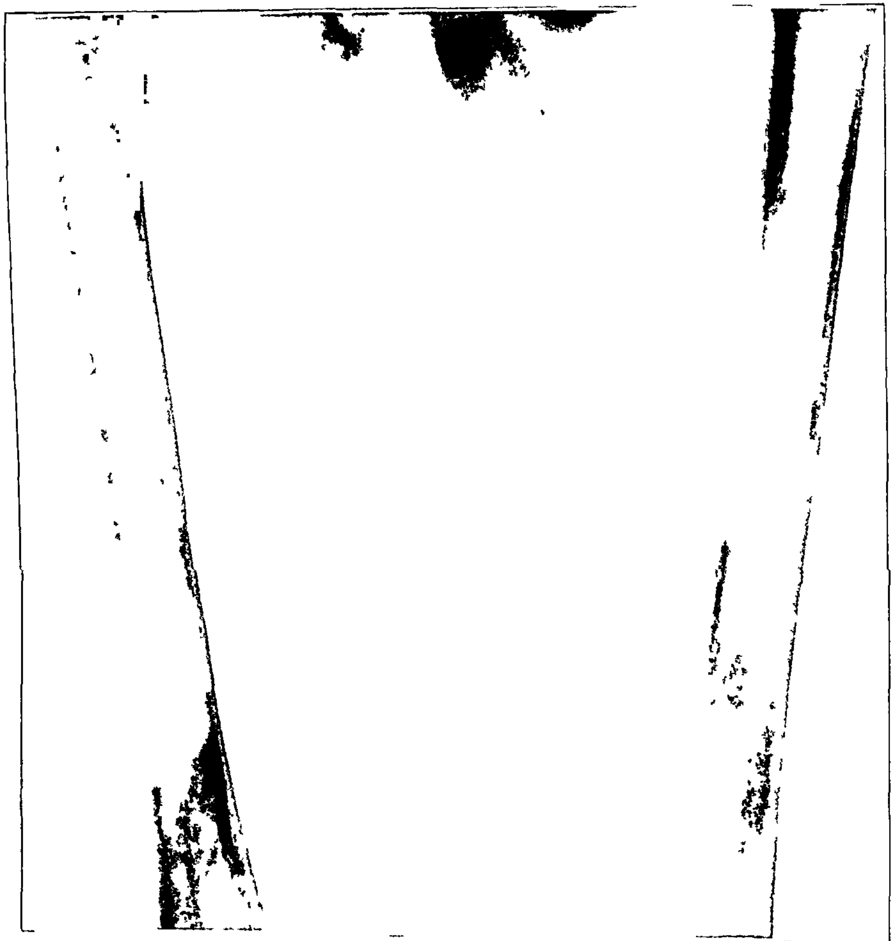

FIG. 2-C

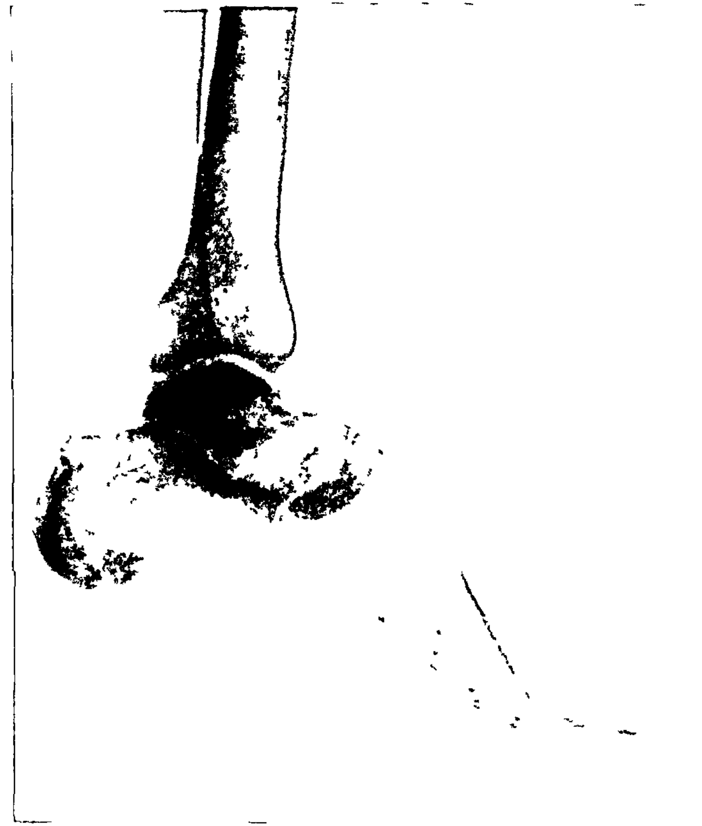

FIG. 2-D

Fig. 2-C. September 29, 1925. Infiltrations into the lower portion of the femora, reminiscent of bone infarcts in caisson disease. These are not typical, however, as there are rarefying changes in the rest of the bones.

Fig. 2-D. November 11, 1933. Dense infiltrations in the left tarsal navicular, suggestive of aseptic necrosis.

tion from weight-bearing while the necrotic-appearing, reorganizing bone and cartilage of the involved joint were still in the plastic stage. It remains to be seen whether further changes during late adolescence and adult life will ensue, including hypertrophic osteoarthritis. However, during the five years in which the girl has been under observation, all changes have been in the direction of improvement and not regression.

Indeed, it is likely that one of the reasons for the advanced degenerative changes seen in adult patients has been the lack of protection in childhood from weight-bearing, during the pliable stages which occur in this hip condition. The following case is an example of this.

CASE 2 (Case 8 in the authors' previous paper and reported in detail by Melamed and Chester.) In this man, S. F., the diagnosis of Gaucher's disease was established by splenic puncture. His symptoms began in 1921, at the age of twelve, and were marked by generalized bone tenderness; by 1930, spinal pain and deformity (gibbus) were present.

Roentgenographic study showed numerous collapsed vertebrae. The pelvis showed cystic changes in the innominate bones, especially near the acetabulum. The femoral heads were flattened and irregularly mushroomed. Cystic changes were present throughout the heads and shafts, with broadening of the latter. The lower ends of the femoral shafts showed the typical clubbing or bottle shape. Other less marked changes were present in the right fibula and tibia, as well as in the left radius and right humerus (Figs. 2-A, 2-B, 2-C, and 2-D). Postmortem examination showed the osseous type of Gaucher's disease. There was involvement of the lymph nodes, liver, spine, pelvis, right humerus, and left radius.

The hip changes were only incidental in the clinical picture and gave rise to few symptoms or signs. Only recently have the patient's original roentgenograms, taken during adolescence, been found in the library of the X-ray Department (Fig. 2-A). These show the earlier condition of the hip joints, which resembled the infiltrative, Legg-Perthes-like process seen in Case 1. This patient had not had adequate protection from weight-bearing during childhood, and this may have been a factor in the deforming change which developed in the hip joints. Here, however, the splenectomy, with its resultant increase of Gaucher-cell deposition in the bone marrow, may have played a major role in causing softening, compression, and degeneration in many of the bones, notably in the spine.

CASE 3. A. S., a male, aged thirty-nine, stated that, in 1921, he had accidentally stepped on a nail and a tetanus infection had developed. Two weeks after this, an infection of the shaft and trochanteric region of the left femur had developed. This required operative intervention on several occasions during the following six years. In 1927, the patient felt well enough to return to his regular work. The entire wound was completely healed, and he was asymptomatic. In February 1933, the patient had a fracture of the left mandible. The roentgenograms taken at that time suggested a pathological fracture. In 1939, he had pain in the right hip region with slight fever. The fever readily subsided, and a diagnosis of arthritis with partial ankylosis of the right hip was made. The patient then returned to his regular work, where he remained for two years.

When next seen, physical examination revealed the following: There was an increase in lumbar lordosis, with a right-thoracic left-lumbar scoliosis. The patient walked with a bilateral hip limp. The Trendelenburg test was positive on the left side. The left lower extremity was one and one-quarter inches shorter than the right. Motion at both hip joints was markedly restricted. In the left hip the angle of greatest flexion was 50 degrees; the angle of greatest extension was 165 degrees. There was marked restriction of adduction and abduction, as well as of internal and external rotation. Motion of the right hip joint was similarly limited. The angle of greatest extension was 165 degrees, and there was marked limitation of abduction and adduction and of internal and external rotation. Abdominal examination disclosed the presence of a large spleen.

Roentgenographic examination of the pelvis, including both hip joints, showed advanced destructive arthritis, strongly resembling aseptic necrosis. Incidentally, a marked increase in density of the fourth lumbar vertebra was seen (Fig. 3).

Significant laboratory tests were the following:

Serum calcium	10 milligrams per 100 cubic centimeters
Serum phosphorus	3.2 milligrams per 100 cubic centimeters
Serum phosphatase	12 King-Armstrong units

The bone-marrow study showed the presence of Gaucher's cells.

In this patient, because of the history of supposed recurrent osteomyelitis, Gaucher's disease was not suspected until roentgenographic studies had been made, which showed the advanced changes in the hips and in the fourth lumbar vertebral body. The splenomegaly was then noted. The diagnosis was made definite by aspiration and biopsy of sternal bone marrow.

FIG. 3

March 23, 1943. Disintegration of both hip joints, due to aseptic necrosis in Gaucher's disease. (Note density of fourth lumbar vertebral body.)

The roentgenographic changes in the hips suggested the end stages of advanced aseptic necrosis of both femoral heads, with more destruction on the left side; some of these changes may have been due to operative trauma or secondary infection, as a result of the several surgical attacks made on the lesion years before. The increased density of the fourth lumbar vertebra is likewise suggestive of aseptic necrosis of the bone, rather than of actual infiltration of Gaucher's cells, which presumably would have caused a rarefied lesion.

CASE 4. S. N., a male, aged fifty, when seen in March 1944, presented the following history: Twenty-six years before, an attack of "sciatica" had developed on the right side, which kept him in bed for six weeks. The pain was intense and radiated from the right hip to the right knee. He entered the United States Army shortly thereafter, and remained well until four years ago. He stated that at that time he had a recurrence of severe pain in the right thigh, which confined him to bed for eight weeks. Thereafter, he remained asymptomatic until two years before admission, when pain developed in his left shoulder. At a Veterans Hospital, a diagnosis of bursitis was made. He was given a course of diathermy and recovered within six weeks. He remained well until one year ago, when severe pain developed in his left hip, radiating down into the left knee. He returned to the Veterans Hospital, where a number of teeth were removed. Diathermy treatments to the left hip were given for a period of seven weeks. The recovery was incomplete, and he continued to have pain in the left hip region. Pain recurred in the left shoulder, associated with progressive limitation of abduction. A limp also developed on the right side, because of recurrent sharp pain in the right thigh and knee.

Physical examination revealed that the patient had great difficulty in bearing weight because of pain in both lower extremities; this pain was located in the hips, thighs, and knees. He walked with a bilateral limp There was marked atrophy of the right thigh and buttock. Motions of the right hip were restricted to a maximum flexion of 100 degrees; adduction and abduction, and internal and external rotation were absent. Motions of the left hip were also markedly restricted in all directions. Abduction of the left shoulder was limited to an angle of 110 degrees.

Roentgenographic examination of the pelvis (done previously at the Mount Sinai Consultation Clinic) disclosed a destructive arthritis of the right hip joint, resembling the aftermath of aseptic necrosis of the femoral head (Figs. 4-A and 4-B). Roentgenographic examination of the right femur showed areas of density in the lower portion of the shaft, resembling aseptic infarction (Fig. 4-C). Roentgenographic examination of the left shoulder suggested aseptic necrosis with degenerative arthritis of the head of the humerus (Fig. 4-D).

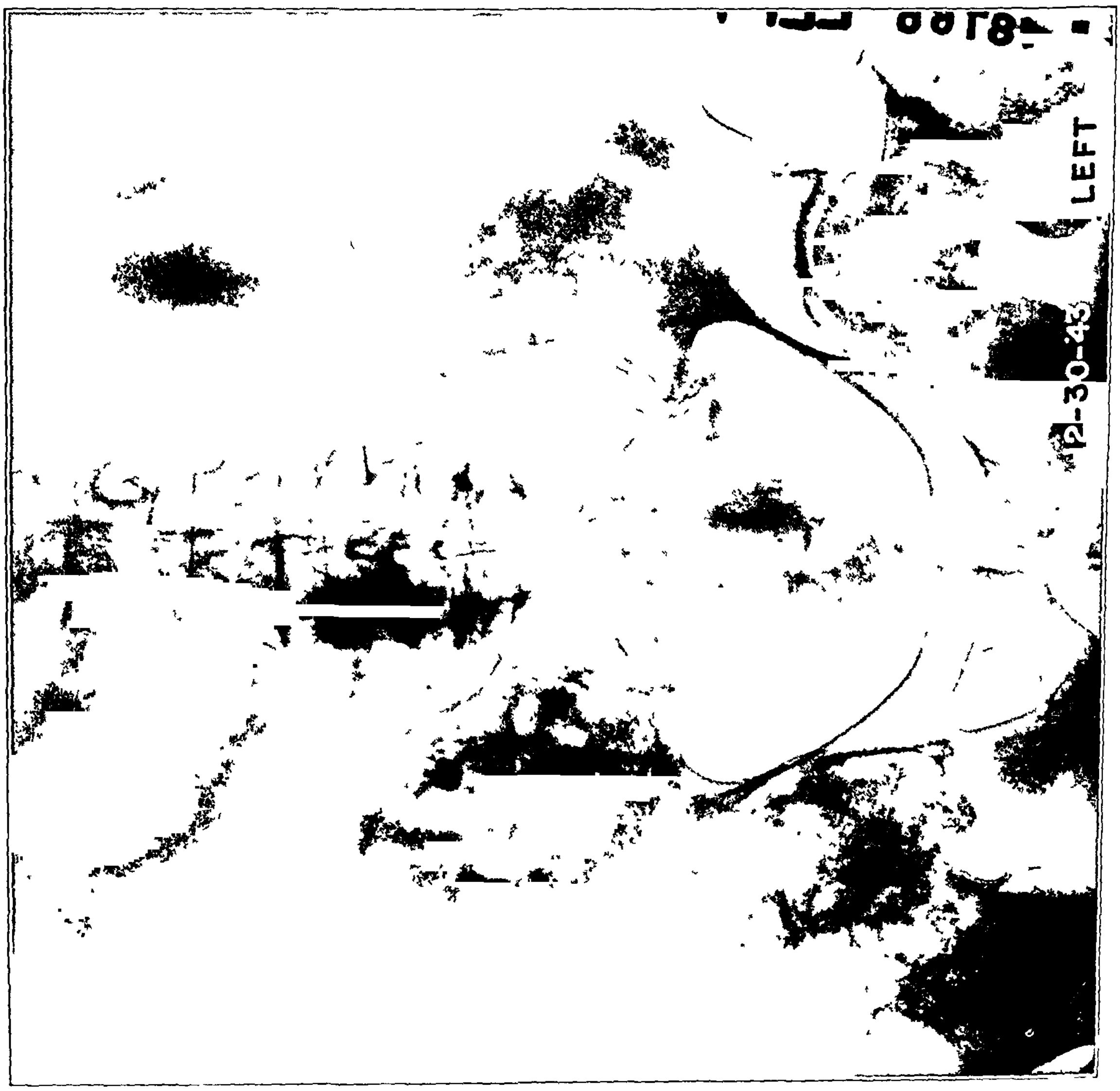

Fig. 4-A

Fig. 4-B

Fig. 4-A: December 30, 1943. Degenerative changes in Gaucher's disease, identical with aseptic necrosis of the femoral head. (Note involvement of adjacent pelvis.)

Fig. 4-B: December 30, 1943. Lateral view of hip shown in Fig. 4-A.

Fig. 1-D

February 11, 1944. Changes in left humeral head, resembling caisson disease.

Fig. 1-C

February 11, 1944. Infarcts in right femur, resembling those seen in caisson disease.

Significant laboratory tests were the following:

Serum calcium	7.4 milligrams per 100 cubic centimeters
Serum phosphorus	2.7 milligrams per 100 cubic centimeters

Sternal-marrow study showed the presence of Gaucher's cells.

In this case, on the basis of the clinical examination and the roentgenographic findings, a tentative diagnosis of caisson disease was entertained, but no corroborative history of industrial or other exposure could be obtained. This case, then, would have corresponded with Phemister's cases of aseptic necrosis of unknown etiology of the femoral heads, humeral head, and a femoral shaft, if a routine sternal-bone-marrow puncture had not shown that the basic nature of the condition was Gaucher's disease. Here, as in several of the other cases, there were no symptoms related to the shaft lesion; and the manifestations in the joints were relatively mild, considering the extensive bone changes.

CASE 5. J. G., a woman, aged twenty-four, had had a diagnosis of Gaucher's disease at the age of thirteen at another hospital, confirmed by sternal-marrow puncture in the Out-Patient Department and wards of the Mount Sinai Hospital. She had had intermittent and chronic anaemia, purpura, weakness, delayed development, and enlargement of the liver and spleen. Recently, the only symptom was pain in the right knee without swelling, but with some restriction of motion. Bilateral bruising and diffuse aches of the lower portions of the legs had habitually been present since childhood.

Physical examination was negative, except for a slightly enlarged liver, which was palpable one finger's breadth below the right costal margin; a huge spleen, reaching down almost to the edge of the pubis, but freely movable and ballotable; and recurrent ecchymoses over the legs and ankles.

Roentgenographic examinations (Fig. 5) of the femoral shafts showed the typical clubbing or "leather-bottle" shape of the lower portion. There were associated rarefying changes in the left femoral shaft, suggesting cyst formation. The upper portion of the left tibia showed a mild sclerosing lesion of the metaphyseal region, reminiscent of absorbing caisson disease or aseptic infarction of bone.

This is another case in which, among the other typical bone changes associated with Gaucher's disease, the areas of increased density in the upper left tibial metaphysis indicated the presence of bone infarction similar to that occurring in caisson disease, but due, not to embolism, but rather to infiltration of Gaucher cells. In caisson disease, shaft lesions away from the joint do not usually cause symptoms, but this patient had a definite history of knee-joint irritation. This frequently accompanies the changes in the lower portion of the femur, associated with Gaucher's disease.

CASE 6. F. R. (Case 7 in the previous paper and Hospital No. 417222). This case was previously reported because of the changes in both hip joints. Of interest was a pathological fracture of the left tibia, two inches below the knee, which occurred in March 1934. This fracture healed slowly, and union was firm in May 1935.

Roentgenographic examination on January 22, 1943 (Fig. 6), showed a femur with typical Gaucher clubbing, infiltration, and cystic changes. The left upper portion of the tibia showed an area of increased density in the medullary metaphyseal region, suggestive of bone infarct as seen in caisson disease. However, this, plus the slight bowing of the upper portion of the left tibia, may be in part due to the old pathological fracture.

DISCUSSION OF PATHOGENESIS

The pathology of this disease has not been studied with special reference to the presence or absence of aseptic necrosis. The most exhaustive study, summarized by Pick, contains no mention of this aspect, although he speaks of large nodules in the medullary cavity, which, however, are not specifically described as of increased density. He speaks of Gaucher-cell infiltration as follows: "Invasion of the head of the femur, with depression fracture and resulting deformity, leads to a deforming arthritis of the hip joint"; but he does not describe in detail the lesions or the increased density which we have uniformly noted in our cases.

Pure Gaucher-cell infiltrations are characterized by radiolucency and rarefied areas in bone. How, then, may we explain the areas of increased density noted in the femoral

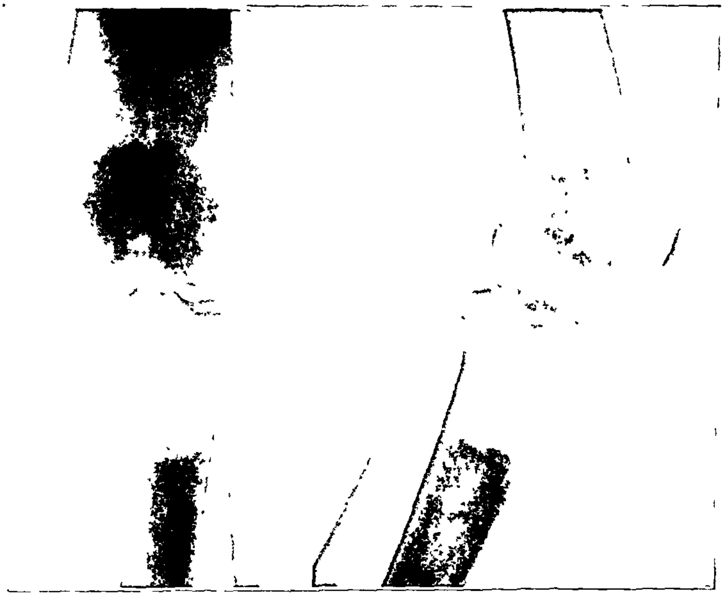

FIG. 5

FIG. 6

Fig. 5: Case 5. Roentgenograms of the left femur, showing typical Gaucher changes. Upper portion of the left tibia shows a mild sclerosing lesion of the metaphyseal region, reminiscent of absorbing caisson disease or aseptic infarction of bone.

Fig. 6: Case 6. January 22, 1943. Typical Gaucher's disease of the left femur, with clubbing, infiltration, and cystic changes. The upper portion of the left tibia shows an increased density in the medullary metaphyseal region, suggestive of bone infarct as seen in caisson disease. Also note slight bowing of upper portion of tibia, due to old pathological fracture.

heads and the shafts of various bones, as mentioned in the case reports? We believe the most likely explanation is that the Gaucher cells, which are known to surround and infiltrate small arteries and capillaries, at times sufficiently cut off circulation to produce aseptic necrosis of bone. Certainly, roentgenographically and clinically, the course closely parallels that of aseptic necrosis of bone of other etiology in which the pathology has been confirmed.

NOTE: The authors gratefully acknowledge their debt to R. K. Lippmann, M.D., who suggested this investigation. Thanks are due to Benjamin B. Greenberg, M.D., for permission to report Case 5.

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COEXISTING MULTIPLE MYELOMA AND PAGET'S DISEASE OF BONE TREATED WITH STILBAMIDINE

BY CARL REICH, M.D., AND ALEXANDER E. BRODSKY, M.D., NEW YORK, N. Y.

From the Lenox Hill Hospital, New York City

The object of this report is, first, to describe a case of coexistent multiple myeloma and Paget's disease of bone (Figs. 1 and 2), and second, to set forth the authors' experiences with stilbamidine in treating this case of multiple myeloma.

The authors have been unable to find any record in the literature of the coexistence of Paget's disease of bone and multiple myeloma, although Snapper [10] had one such case, confirmed by necropsy. The diagnosis of multiple myeloma was definitely established in this case by sternal-marrow studies, but no biopsy material could be obtained from the affected left hip. However, the roentgenographic appearance of the femur unquestionably fulfills the classical criteria of Paget's disease of bone.

The authors are unable to explain the appearance of these two disease entities in their patient, or to postulate any tenable cause-and-effect relationship of the two. However, we feel that it is important, especially for diagnostic significance and for proper management of the patient, to point out that the two may coexist. Upon looking at the patient's roentgenograms, one might at first be tempted to explain the picture on the basis of Paget's disease alone, for the areas of circumscribed osteoporosis, which in this case were caused by multiple myeloma, could have been interpreted as the "osteoporosis circumscripta" of early Paget lesions, which they resemble [3,7].

The patient reported here was treated elsewhere for four years without the multiple myeloma being detected, but, after diagnosis had been established, stilbamidine therapy relieved his pain. Thus it may well be that similar cases have occurred, where the multiple myeloma was not diagnosed because of the absence of Bence-Jones proteinuria and because sternal-marrow studies were not done.

The frequency with which multiple myeloma and Paget's disease are to be found in the same patient is a matter for speculation. However, those who have reported on the pathology of Paget's disease have failed to mention plasmocytic changes in the marrow of such patients at necropsy [3,5,6], and Tronchetti failed to note any characteristic or unusual features in the marrow of three patients with Paget's disease. Nevertheless, we believe that the case reported here would indicate the advisability of excluding multiple myeloma, by means of bone-marrow studies, in those cases of Paget's disease where there are areas of circumscribed osteoporosis, even in the absence of Bence-Jones proteinuria and hyperglobulinaemia.

Because the roentgenographic appearance of Paget's disease occasionally is simulated by metastases of carcinoma of the prostate, a careful work-up was done to exclude this possibility; no prostatic or other condition that might produce this picture was found. The additional possibility of multiple myeloma producing Paget-like changes in the roentgenogram can be ruled out by the absence of any mention of such an occurrence in the numerous reports on multiple myeloma [1,2]. All accounts of multiple myeloma concur in describing the bone lesion as a discrete area of decalcification, distinguished by the complete absence of any adjacent sclerosis and altogether without any resemblance to Paget's disease (Fig. 2).

CASE REPORT

W. L., a white salesman, fifty-two years old, was admitted on November 11, 1946, complaining of constant pain, of four years' duration, in the entire back and in the anterolateral portions of both sides of the thorax, as well as recurrent, mild aching pain in both shoulders. He had become round-shouldered and shorter

in height. Prior to admission, the patient had been treated for "arthritis of the spine": he had received physiotherapy, orthopaedic appliances, and various injected medications elsewhere without benefit. He had been forced to stop working three years before, and had lost forty pounds during the past few years, from a previous high of 216 pounds. He had noted no increase in hat or glove size.

His past history revealed that a cholecystectomy had been performed in 1936, followed by wound dehiscence and postoperative pneumonia. A large incisional hernia ensued, and was repaired successfully in December 1945. He had had pneumonia twelve times since 1919, with the last nine episodes occurring in the past four or five years, usually biannually. The response to chemotherapy had always been prompt, with complete resolution. The last such attack occurred during the present stay in the hospital, and resembled the previous attacks. For several years he had noted hoarseness and a chronic cough, which he attributed to excessive smoking.

Examination disclosed a heavy-set, well-nourished white male of swarthy complexion with a protuberant abdomen. he stood on a widened base, with his hands on his hips in an effort to maintain erect posture. There was no definite limp, but his gait lacked normal resiliency. The entire thoracolumbar spine was completely rigid, with loss of lumbar lordosis and with tenderness to percussion over the lumbar spine. There was moderate limitation of abduction and internal rotation of both hips, but motion of the shoulders and cervical spine was normal. The head was free of tenderness, enlargement, asymmetry, deformity, or exostoses. Mirror examination of the larynx revealed diffusely oedematous hyperaemic vocal cords which moved sluggishly. The thorax was emphysematous, with point tenderness along the eighth and ninth ribs in the anterior axillary line on the right. In both hilar regions there were moist rhonchi which disappeared after coughing. The abdomen was negative, except for a healed transverse incisional scar in the right upper quadrant. Rectal examination was negative, revealing a soft, symmetrical, non-tender, small prostate.

Roentgenographic examination showed marked diffuse osteoporosis of the thoracolumbar spine with ballooning of the intervertebral discs and wedging and compression of the bodies of the fourth, sixth, seventh, and eighth thoracic vertebrae. The cervical spine was well calcified and showed only mild hypertrophic changes. The upper portion of the left femur presented the characteristic picture of Paget's disease of bone (expansion of the cortex, irregularity of the medullary canal, cotton-wool irregularity of the periosteal contours, cross-hatch striations, and areas of decreased bone density, irregularly interspersed with areas of bone

FIG. 1

Roentgenogram of the pelvis, showing Paget's disease of the upper portion of the left femur, and, in the upper portion of the right femur, two large, sharply circumscribed punched-out areas in the intertrochanteric region. Less readily apparent are the many small decalcified areas in the pubic rami. (This roentgenogram has been reversed.)

FIG. 2

Fig. 2: Roentgenogram of the right shoulder, taken at the same time as Fig. 1, illustrates numerous cystic areas of varying sizes in the upper portion of the humerus. There is no adjacent bone sclerosis. The diffuse mottling of the ribs by similar punctate decalcifications is quite striking.

FIG. 3

Fig. 3: Photomicrograph shows a myeloma cell containing large basophilic granules in the cytoplasm, after completion of the stilbamidine therapy. These granules were not present in any of the myeloma cells before treatment. Note the eccentrically placed nucleus and the large nucleolus.

sclerosis). The upper portion of the right femur showed several moderately large decalcified areas without adjacent sclerosis. Similar areas, from one to three centimeters in diameter, were present in the upper portions of both humeri, and punctate decalcification of the ribs was noted. The chest plates showed only accentuation of the bronchovascular markings. The skull films were negative, except for increased vascular markings.

Blood count and urinalysis were normal, except that in the former there was a relative lymphocytosis. The blood serum calcium (10 milligrams per 100 cubic centimeters), serum phosphorus (3.3 milligrams per 100 cubic centimeters), and alkaline phosphatase (5.6 Bodansky units) were also within normal limits. Numerous examinations of the urine for Bence-Jones protein were negative. Other laboratory tests were within normal limits.

With these findings, there was a tendency to attribute the patient's symptoms and his appearance to Paget's disease. The possibility of coexisting osteitis fibrosa cystica was entertained, but this was later regarded as untenable. The presence of multiple myeloma was suspected, because of the roentgenographic appearance of the decalcified areas in the shoulders, ribs, and right femur, in spite of the absence of Bence-Jones proteinuria. Therefore, after a positive formol-gel test for hyperglobulinaemia, and the discovery of a high total serum protein (11.1 grams per 100 cubic centimeters) and a high serum globulin (6.9 grams per 100 cubic centimeters), a sternal-marrow aspiration was performed. The presence of large numbers of myeloma cells conclusively established the diagnosis of multiple myeloma. The material obtained at three separate sternal punctures—one before stilbamidine therapy, on November 22, 1946, and the last two after the institution of stilbamidine treatment, on January 3, 1947, and January 25, 1947—all showed a bone marrow greatly infiltrated by myeloma cells. Two types of myeloma cells were noted, which, for descriptive purposes, are designated as plasma myeloma cells and plasmablast myeloma cells. The plasma myeloma cell is the one usually regarded as the typical cell of multiple myeloma, and was characterized by an irregularly stained cytoplasm and an eccentrically placed nucleus with perinuclear halo. The nuclear chromatin of this cell was well condensed and stained deeply. However, there were other forms, which we term "plasmablast myeloma cells", much larger in size, with pale, evenly stained cytoplasm, a much larger nucleus with finely stippled chromatin, a nucleolus, and occasionally evidence of amitotic division.

On November 22, 1946, the patient experienced severe shaking chills and malaise, followed by a rise in temperature to 105.4 degrees within three hours, and a cough productive of blood-tinged sputum. Examination revealed only persistent moist râles posteriorly, over the lower lobe of the right lung field. Penicillin was started immediately (50,000 units every three hours for the first twelve hours, and then 30,000 units every three hours for five days). Chest roentgenograms revealed a wedge-shaped consolidation, extending from the hilus into the right lower lobe. Sputum culture disclosed no specific organism. His temperature dropped to 100.2 degrees within twelve hours and to normal within seventy-two hours, with disappearance of all symptoms and with the uneventful resolution of the pulmonary consolidation.

Dr. I. Snapper saw the patient in consultation on December 11, 1946, and concurred in the diagnosis of multiple myeloma and Paget's disease. The patient was then placed on a diet free of all animal protein except for fourteen ounces of milk, three small servings of butter, and two ounces of light cream daily. He remained

on this diet for six and one-half weeks, throughout the period of stilbamidine therapy. A total dosage of 2.85 grams of stilbamidine was administered intravenously in twenty injections, usually on alternating days. Some of the undesirable side effects encountered early in the treatment will be discussed, as well as the manner in which they can be obviated in other cases. After the fifth injection (a total of 0.7 gram of stilbamidine), the patient volunteered that he no longer experienced any back or chest pain. A sternal puncture soon after this, on January 3, 1947 (after 1.4 grams of stilbamidine), showed that the cytoplasm of the myeloma cells contained aggregations of small basophilic granules which had not been present prior to treatment. At that time there was over 50 per cent. return of mobility of the thoracolumbar spine; and, at the conclusion of therapy, spine motion was almost completely normal. After the completion of therapy, on January 23, 1947, a sternal puncture revealed large numbers of the basophilic granules in the cytoplasm of the myeloma cells, but no other changes in the number or morphology of these cells. The other cells of the marrow contained none of the granules, and were unaltered in appearance or distribution. There were no significant alterations in differential marrow counts in the three sternal-marrow specimens. Since discharge from the Hospital, on January 26, 1947, the patient has remained free from pain and has led a relatively active life.

DISCUSSION

The significance of this report lies chiefly in the coexistence of multiple myeloma and Paget's disease of bone; but, in addition, some of the experiences with stilbamidine will be presented.

Favorable influence on the symptoms of multiple myeloma by the diamidine compounds, stilbamidine and pentamidine, has been set forth in several recent articles by Snapper; and it was decided to try stilbamidine in this case, in view of the generally poor results from other forms of therapy. The patient was relieved of all pain after the fifth injection (0.7 gram of stilbamidine), and soon after regained painless motion of the spine. This clinical benefit (which has continued to date) coincided with the appearance of basophilic granules in the cytoplasm of the myeloma cells (Fig. 3), which were not present in the specimen examined before treatment. The authors believe that the improvement is to be attributed to the drug and not to any natural remission of the disease, as described by Geschickter and Copeland, or to any non-specific therapeutic effect. For four years there had been no remission of pain and no relief from a variety of non-specific therapeutic measures.

As a result of experience with this case, we wish to emphasize that stilbamidine can produce distressing side effects, which can easily be obviated by certain simple precautions. The powder should be dissolved in a sterile fashion in about ten cubic centimeters of sterile distilled water and administered very slowly intravenously, preferably with a small-gauge needle. The patient should be supine during and for a short while after the injection, for the drug has a powerful vasodilator action, producing a fall in blood pressure; with the patient in the upright position, this may cause syncope and collapse. Within less than a minute after the beginning of an injection, the patient noted the rapid spread of a sensation of heat in the face, scalp, perineum, and, at times, in the extremities, accompanied by the appearance of flushing and sweating. After rising to a peak a few minutes after the injection was completed, the blushing, sweating, and sensation of warmth waned rapidly. This patient experienced no dizziness, nausea, or formication, as mentioned by Snapper [8]; but when, early in the course of treatment, an injection was given when he was in the sitting position, syncope ensued within a few minutes with transient clonic movements of the extremities, a feeble pulse, and involuntary urination. The patient recovered immediately after being placed in bed in the Trendelenburg position. The inadvertent extravenous injection of a small quantity of the solution, on another occasion, was followed by localized pain and swelling which persisted for several days. No adverse effects of treatment were observed on renal function, hemoglobin, red or white blood cell count, or the state of general health. No change in the number or morphology of the abnormal cells, other than the appearance of the granules, has been seen by the authors. Likewise, there have been no alterations in the morphology or numbers of the other cellular elements of the bone marrow, or in those of the peripheral blood. Roentgenographic examination of the

skeleton, following treatment, disclosed no appreciable change in the lesions previously noted.

The basophilic granules which appeared in the cytoplasm of the myeloma cells have been described by Snapper, and have been shown to consist of stilbamidine ribonucleate [4,8]. These granules were present in the sternal-marrow specimen taken after the tenth injection (a total of 1.4 grams of drug), but were seen in greater abundance after the conclusion of therapy.

No curative value has been claimed for stilbamidine, but it has proved to be an effective means of relieving the pain of many patients suffering from multiple myeloma. Its side effects can be avoided if certain simple precautions are observed.

CONCLUSIONS

Although present evidence does not indicate any relationship between multiple myeloma and Paget's disease of bone, the authors feel that multiple myeloma should be ruled out, by marrow aspiration or biopsy, in those cases of Paget's disease with well-defined areas of decalcification and no adjacent sclerosis.

In the case presented, treatment with stilbamidine (a total of 2.85 grams) caused early disappearance of all pain and increased spinal mobility. Basophilic granules, which had not been present prior to therapy, appeared in the cytoplasm of the myeloma cells. The patient experienced no serious or permanent ill effects attributable to therapy. The transitory ill effects accompanying the administration of stilbamidine can be avoided by certain simple precautions.

NOTE: The authors are indebted to Dr. Henry H. Jordan for permitting these studies to be made on his patient; to Dr. D. F. Robertson and Dr. I. Snapper for the supply of stilbamidine; and to Dr. Snapper for valuable advice.

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CUP ARTHROPLASTY OF THE HIP*

BY WILLIAM H. BICKEL, M.D., ROCHESTER, MINNESOTA

Section on Orthopaedic Surgery, Mayo Clinic

AND FRANK S. BABB, M.D., ROCHESTER, MINNESOTA

Fellow in Orthopaedic Surgery, Mayo Foundation

A preliminary survey [1] of the results of cup arthroplasty of the hip was made in November 1944, in cases in which operation had been performed at the Mayo Clinic from June 1939 through December 1942. Although the results in all cases were not all that could be desired, they were sufficiently encouraging to justify continued use of this operative procedure. At that time 111 operations, performed on ninety-one patients, were considered. From 1943 through 1945, cup arthroplasty was performed 163 times on 142 patients; this makes a total of 274 hips and 233 patients treated in this way from 1939 to 1945, inclusive. A complete follow-up of the entire group now has been made. No cases are included in this report in which operation was not done at least one year prior to the date of evaluation. All patients have been heard from or examined within the past year.

PATHOLOGICAL CONDITIONS

Although in many instances the cause of a distorted hip can be determined from the history and from the clinical and roentgenographic findings, this is not always possible. Degenerative disease of the hip, commonly known as malum coxae senilis, embraces varied pathological conditions, the onset of which may not be remembered or the symptoms from which may have been subclinical. Mild slipping of the femoral epiphysis, or Legg-Perthes disease, congenitally shallow acetabula, and other conditions would fall into this group. Post-traumatic hypertrophic changes are difficult to distinguish from the changes due to "osteo-arthritis of the hip".

The various conditions for which cup arthroplasties have been performed are summarized in Tables I and II.

SELECTION OF CASES

With few exceptions, patients who were advised to have cup arthroplasties at the Clinic were having sufficient pain so that they demanded operative interference for its

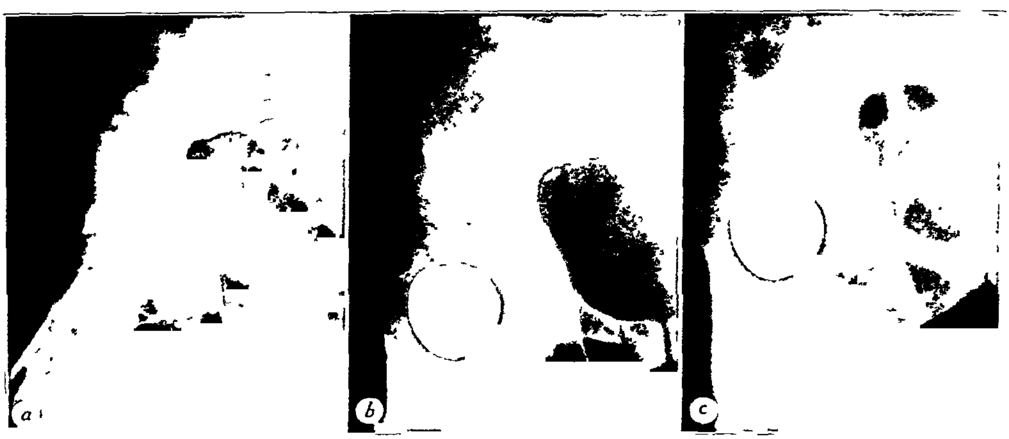

FIG. 1

Old healed pyogenic infection of the hip with abduction flexion deformity and fibrous ankylosis. Six years and seven months after operation, the result was good. *a*, Before operation; *b*, four months after Vitallium-cup arthroplasty, showing short neck and portion of head left in acetabulum. *c*, seventeen months after operation, motion and function were good. Old head had been incorporated into acetabulum.

* Received for publication in August 1947.

TABLE I

RESULTS OF UNILATERAL CUP ARTHROPLASTY FOR VARIOUS CONDITIONS IN 192 CASES (1939 TO 1945, INCLUSIVE) *

Pathological Lesion	Patients Traced †	Results			
		Very Good (Per cent.)	Good (Per cent.)	Fair (Per cent.)	Poor (Per cent.)
Osteo-arthritis	74	15	36	19	30
Post-traumatic arthritis	35	29	40	14	17
Aseptic necrosis 23		22	39	22	17
Hypertrophic arthritis 12		42	42		16
Old healed pyogenic infection of hip	21	33	33	5	29
Old slipped epiphysis	17	12	29	35	24
Congenital dislocation	10	20	60	20	
Rheumatoid spondylitis	8	12		38	50
Rheumatoid arthritis	6	50		33	17
Otto pelvis	3		67	33	
Legg-Perthes disease	2	50			50
Osteochondritis dissecans	2		100		
Postgonococcal arthritis	1				
Total and averages	179	21	35	19	25

* Follow-up data to February 1947.
† Thirteen patients were not traced.

relief. In some cases the fixed deformity alone was sufficient to require correction (Fig. 1) In cases in which both hips (Figs. 2 and 3) were affected, the surgeon had no choice except to perform cup arthroplasty in an attempt to obtain at least one movable hip.

Many patients who felt that they were having sufficient distress to warrant an operation were advised to pursue a course of conservative treatment. This consisted in limited activity, reduction of weight, use of a cane or crutch, physical therapy, and the taking of aspirin. Aged patients and those whose distress the examining physician considered not too severe were included in this group. Some additional patients were advised to continue

FIG. 2

Bilateral rheumatoid arthritis of hip with pain and fibrous ankylosis. Five years and six months after operation, the result was still poor. *a*, Before operation; *b*, eight months after bilateral cup operation, the result was poor.

FIG. 3
Otto pelvis, four years after operation, the result was good. *a*, Before operation, *b*, eleven months after operation Extensive acetabuloplasty had been done; motion was good.

FIG. 4
Old slipped epiphysis with very shallow acetabulum and gross deformity of the head of the femur; good result four years and seven months after operation. *a*, Before operation: *b*, seventeen months after operation, showing shallow but adequate acetabulum.

conservative treatment, because medical examinations indicated that the risk of this operative procedure was great for them.

Patients who had unilateral disease of the hip and whose occupations required heavy manual labor were advised to have arthrodesis of the hip rather than cup arthroplasty. A few patients absolutely refused to permit arthrodesis of the hip. The possibility of a failure after cup arthroplasty was discussed with these patients, and they were told that arthrodesis could be carried out if cup arthroplasty failed.

TABLE II

RESULTS OF BILATERAL CUP ARTHROPLASTY FOR VARIOUS CONDITIONS IN FORTY-ONE CASES (1939 TO 1945, INCLUSIVE)*

Pathological Lesion	Patients Traced †	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Osteo-arthritis.	9	11	33	45	11
Old healed pyogenic infection of hip . .	2		50		50
Old slipped epiphysis. . .	1		100		
Congenital dislocation. .	2		50	50	
Rheumatoid spondylitis	12		33	17	50
Rheumatoid arthritis. .	9	11	33	33	22
Otto pelvis.	1			100	
Legg-Perthes disease.	2	50			50
Total and averages	38	8	34	29	29

* Follow-up data to February 1947.
† Three patients were not traced.

Aged persons who were not in good condition were excluded from the group operated upon. The physiological age appeared to be less than the chronological age for most of the patients who were in the age group from sixty to sixty-nine years. Included also were a few adolescent patients, who presented such severe conditions that operative treatment was necessary. Full growth should be obtained, if possible, before cup arthroplasty is undertaken. One of the patients in this series, who was only twelve years of age, presented a difficult problem because of aplastic congenitally dislocated hips. Arthroplasty, for which a lucite cup was employed, was performed; and the result, four years after operation, was good.

SURGICAL TREATMENT

No special immediate preoperative preparation is necessary in these cases. Patients who are greatly overweight are forced to reduce before cup arthroplasty is undertaken.

TABLE III

RESULTS OF UNILATERAL CUP ARTHROPLASTY ACCORDING TO AGE GROUPS IN 192 CASES (1939 TO 1945, INCLUSIVE)

Age (*Years*)	Patients Traced *	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Less than 30. .	31	29	32	10	29
30 to 39. . .	35	31	38	17	14
40 to 49. . .	34	9	39	26	26
50 to 59. . .	49	22	29	22	27
60 to 69. . . .	26	12	42	19	27
70 and over. . .	4		50		50
Total and averages .	179	21	35	19	25

* Thirteen patients were not traced.

No detailed description of the operative technique is indicated, for, in the main, that advocated by Smith-Petersen was employed. Various modifications were made, as dictated by the individual case and the desires of the surgeon.

When the acetabulum was too shallow for the cup, it was either reamed out to allow room for a freely movable cup (Fig. 4) or supplemented by a shelf to make it sufficient. In cases in which ankylosis was nearly complete and a deep acetabulum was present, a portion of the head of the femur was left in the acetabulum to make it more shallow (Fig. 1). Radical acetabuloplasty was done in some instances, so that the cup did not sink within the rim of the acetabulum. This procedure was employed most frequently in cases of arthrokatadysis (Fig. 3). The head of the femur was always trimmed sufficiently to allow the cup to move freely on it (Fig. 5).

From the roentgenograms, it was obvious that in some cases the hips were unsuited mechanically for a routine cup arthroplasty. The head of the femur was small and the neck short, or there was a severe distortion of the neck. Early in the series some attempts were made to perform cup arthroplasty on such hips, with poor results (Fig. 6). Although only two cases of bilateral Legg-Perthes disease and two of unilateral Legg-Perthes disease are included in this report, cup arthroplasty has been performed in several more

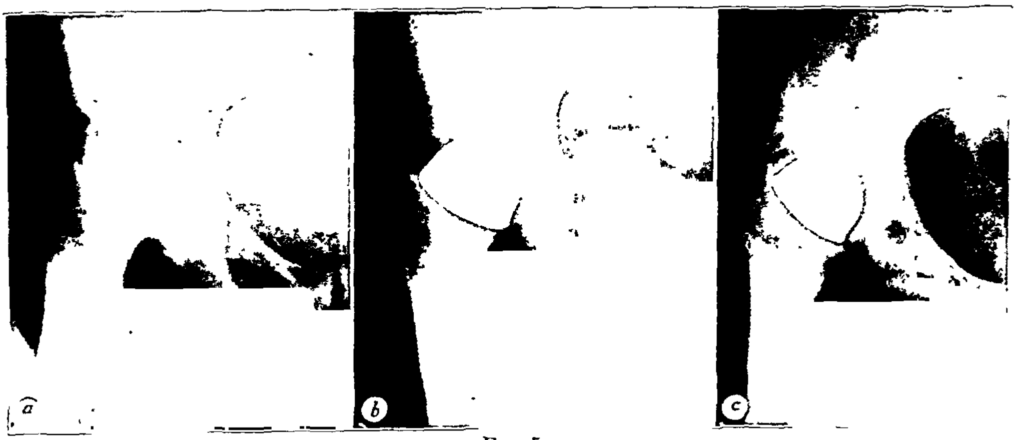

Fig. 5

Extensive osteo-arthritis of hip with lipping, sclerosis, and cystic changes; the result, six years after operation, was very good. *a*, Before operation, *b*, one month after operation, there was extensive trimming down of head and neck; *c*, seventeen months after operation, showing absorption of neck beneath the cup and a low riding cup.

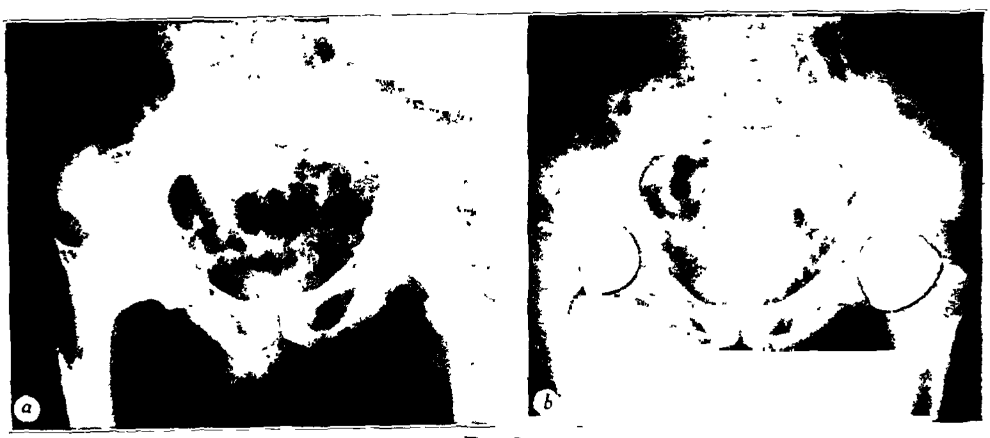

Fig. 6

Bilateral coxa vara and questionable Legg-Perthes disease. *a*, Before operation; *b*, fourteen months after operation. Poor position of cup was attendant on unsuitable angle of neck for retention; the result was poor.

TABLE IV

RESULTS OF BILATERAL CUP ARTHROPLASTY ACCORDING TO AGE GROUPS IN FORTY-ONE CASES (1939 TO 1945, INCLUSIVE)

Age (*Years*)	Patients Traced *	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Less than 30	12		33	33	34
30 to 39	14	14	28	21	37
40 to 49	3		67		33
50 to 59	7		43	43	14
60 to 69	2	50		50	
Total and averages	38	8	34	29	29

* Three patients were not traced.

cases since data for this report were collected. Deformity due to Legg-Perthes disease is a most difficult type of deformity to deal with. The distorted neck and head of the femur frequently are in severe varus position and the acetabulum is shallow and slanting. The results, as indicated in Tables I and II, were not dependably good. Now a more extensive reconstruction is done, such as a Whitman operation or a Colonna operation, supplemented by a cup.

After operation a Hodgen splint was applied, with moleskin traction on the extremity to hold it in internal rotation and abduction until the wound was healed. This usually took from twelve to fourteen days. An arthroplasty splint was then applied. The patient usually indicated when he felt able to be about on crutches. Most frequently he was able to do this in a little less than three weeks after operation. Some, but not all, of the patients were given physical therapy. In four to six weeks the patients were usually allowed to go home.

The time at which weight-bearing was permitted depended somewhat upon how extensively the head of the femur had been remodeled. If considerable cortical bone was

TABLE V

RESULTS OF UNILATERAL CUP ARTHROPLASTY ACCORDING TO SEX AND TYPE OF CUP IN 192 CASES (1939 TO 1945, INCLUSIVE)

	Patients Traced *	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Males	105	23	32	17	28
Females	74	18	38	22	22
Total and averages	179	21	35	19	25
Vitallium	143	21	40	17	22
Lucite	*36*	*19*	*19*	*25*	*37*
Total and averages	179	21	35	19	25

* Thirteen patients were not traced.

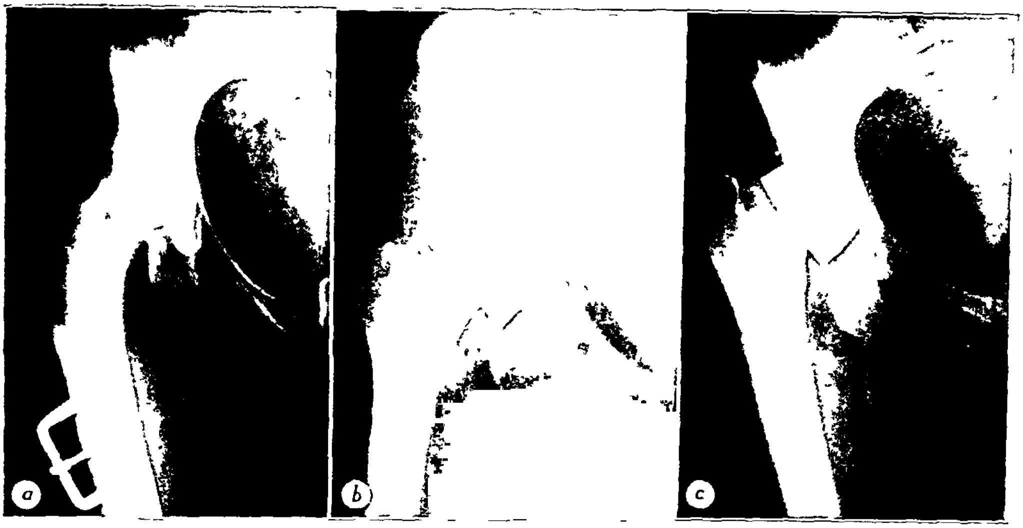

FIG. 7
Postpneumonic infection of hip of one year's duration; the result, seven years after operation, was very good. *a*, Before operation; *b*, two weeks after cup arthroplasty; *c*, seventeen months after operation. Early weight-bearing may have caused absorption of neck of femur.

FIG. 8
Old traumatic dislocation of right hip with resultant aseptic necrosis and traumatic arthritis. Five years after operation, the result was good. *a*, Before operation; *b*, immediately after lucite-cup arthroplasty; *c*, two years after operation, showing marked degenerative changes with poor result. There was a question as to whether or not the cup had been fractured.

left, full weight-bearing was allowed early. When it was necessary to trim the head down to cancellous bone, more time was allowed for healing and reorganization of this surface before full weight-bearing was permitted (Fig. 7). Usually a period of four to six months was recommended.

POSTOPERATIVE COMPLICATIONS

Infections in the wound occurred in ten cases. Three of these infections were inconsequential and superficial. The end results were good in two of these three cases and poor in one case. In two instances the infections were deep, but the wounds subsequently healed with the cups in place; the end results in these two cases were poor. In five cases. drainage continued until the cups had been removed; the end results were poor in four cases and fair in one case. In one of this last group, the infection was felt to be blood borne. since drainage did not appear until five months after operation. Drainage was still occurring four years after operation. Thrombophlebitis developed in one case after operation.

In three patients, dislocation of the cups occurred. One was replaced surgically two

TABLE VI

RESULTS OF BILATERAL CUP ARTHROPLASTY ACCORDING TO SEX IN FORTY-ONE CASES (1939 TO 1945, INCLUSIVE)

Sex	Patients Traced *	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
Males	27	12	33	22	33
Females	11		36	46	18
Total and averages	38	8	34	29	29

* Three patients were not traced.

TABLE VII

TREND OF RESULTS

Operations	Patients Traced	Results			
		Very Good (*Per cent.*)	Good (*Per cent.*)	Fair (*Per cent.*)	Poor (*Per cent.*)
1939 to 1942	88	17	24	28	31
1939 to 1945	217	18	35	21	26

weeks after operation and a very good result was obtained. One was replaced by manipulation under anaesthesia, but the final result was poor enough so that arthrodesis was done later. In the third case, further operation was performed elsewhere because of the poor result. In several cases the position of the cup was poor and manipulations were carried out postoperatively, with successful repositioning.

Excessive proliferation of bone about the cup and the hip occurred in two cases in which the disease was unilateral, and ankylosis recurred in both hips in a case of rheumatoid arthritis. It is felt that, if late postoperative roentgenograms could be obtained in all cases, bony proliferation about the cup might be disclosed, which would account for some of the poor results that have not been explained.

A rather unique and unclassifiable group of cases were those in which Vitallium-cup arthroplasty was employed without success, and the cup then was removed and not replaced. In one case of unilateral disease in which this occurred, a good result was obtained. In two cases in which bilateral operation had been performed, the cups were removed, and a Colonna type of pseudarthrosis was established. In both of these cases, the hips had been ankylosed at 90 degrees of flexion. Even though the patients walked with canes, the end result was considered good, because the severe preoperative disability had been lessened and the patients seemed well satisfied with the results. One patient, who had undergone a bilateral operation in which Vitallium cups were inserted, had one cup removed without any replacement. The result continued to be poor. A second arthroplasty, in which a Vitallium cup was used, was done in two cases after the head of the femur had been remodeled. Good results were obtained.

In five cases of unilateral disease, fractured lucite cups were removed at operation (Fig. 8). In cases of bilateral disease, six fractured lucite cups were removed. Secondary procedures carried out on these patients were simple removal, replacement with Vitallium

cups, and arthrodesis. The end results varied. In four additional cases in which lucite-cup arthroplasty was employed, the cups probably have been fractured, but exploratory operation has not been carried out.

In one case, the femur was fractured during the attempt to dislocate the hip at operation. Union was obtained, and later Vitallium-cup arthroplasty was done with a fair result.

RESULTS

The result was considered to be *very good* when the patient had no pain, could walk up and down stairs, tie his shoes, and walk without assistance and without a noticeable limp. A *good* result was considered to have been obtained when the patient had little or no pain, could walk up and down stairs, and could walk without assistance or with the help of a cane.

Patients were considered to have a *fair* result when they were satisfied that improvement had been obtained. Pain sometimes persisted, but it was less severe than before operation and was bearable. Motion may or may not have been improved. Many patients still used a cane or a crutch. Frequently deformity and grossly abnormal gaits were improved, but some disability persisted.

The *poor* results were those in which the condition was not improved by the procedure and the patient was not satisfied. Only a few patients felt that they were made worse by the operation.

A detailed statistical analysis has not been included in this paper, but the more important results have been summarized in Tables I to VI. The results in cases in which unilateral operations were performed have been summarized separately from those in which bilateral operations were carried out. The breakdown was considered necessary, because the patient's condition must be analyzed as a unit, when his ability to move about is considered. As stated previously, all patients have been followed within the past year and all operations have been performed at least one year before the follow-up. Some patients were operated upon more than seven years before this study.

The greatest percentage of good and very good results were obtained among patients of middle age, with a tapering off in the younger and older ages (Tables III and IV). Apparently there is little sex preference (Tables V and VI); if anything, the females did slightly better than the males. This may perhaps be explained by the fact that males use their hips for heavier work than do females.

COMMENT

Detailed analysis of these cases revealed that patients should be selected carefully for cup arthroplasty on the basis of (1) physiological age, (2) temperament and ability to cooperate, (3) reconstructive possibilities of the hip, as analyzed from roentgenograms, (4) muscle power, and (5) occupation.

All patients should be acquainted with the possibilities of failure and success, and the alternate operations should be discussed with them. In case of disease of both hips, or in cases in which degeneration of the opposite hip is expected, there is no alternative. Drilling operations, cheilotomy, fascial arthroplasty, and other methods have not stood the test of time. Osteotomy to change the weight-bearing surfaces of an already incongruous and worn-out joint does not seem reasonable. Neurectomy of the obturator nerve may help. It has not proved of great help in relieving persistent pain following cup arthroplasty; in our hands, however, the number of cases in which it has been done is not great.

Prostigmine has been used after operation in some cases to relieve muscle spasm and pain. The results were not very encouraging, although several patients felt that it helped considerably. Curare has been used in conjunction with physical therapy in a few cases to obtain muscle relaxation, with equivocal results thus far.

Some of the best results obtained have been in cases in which the degenerative process or mechanical irregularity of the head of the femur was in the formative stage and the acetabulum was involved only mildly. It is difficult to advise early operation for a patient who has distortion of the hip joint without much pain, although one knows that ultimately the hip will break down. Perhaps in these cases, cup arthroplasties should be done before secondary osteo-arthritis develops (Fig. 8).

Comparison of the results recorded in the eighty-eight cases in which cup arthroplasty was carried out at the Clinic prior to January 1943, with the results recorded in these same cases in this report, reveals a slight trend toward improvement. In nineteen cases in which unilateral cup arthroplasty had been performed prior to 1943, improvement had occurred in the past three years as follows: In six cases results which were poor at the time of the first study had become fair; in six cases fair results had changed to good; and in one case fair results had become excellent. In six cases results which were good earlier had become very good. In ten cases the results had become worse; in five of these cases lucite cups had been used. The lucite cups in three of these cases are known to have fractured; one patient had a late abscess. No reason could be found for the downhill course of the remaining six patients. Results in four cases went from fair to poor; in three from good to poor (lucite cups); in two from good to fair; and in one from very good to good.

It is our impression that, as the patients gain confidence and muscle strength, the motion in their hips generally becomes better and the pain becomes less. Table VII illustrates the over-all trend in all cases in which follow-up information was available.

Those opposed to cup arthroplasty will focus their attention on the percentage of poor results. It must be remembered, however, that the patients were severely disabled before operation, and that the percentage of salvaged individuals far outweighs the percentage of those who have been made no better.

From this study it seems safe to conclude that Vitallium-cup arthroplasty of the hip is a procedure which offers relief from pain, increased motion, and correction of deformity to a great number of patients. The results cannot be positively predicted, but better selection of patients and improvement in surgical technique should increase the percentage of good results from this surgical procedure.

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AN EVALUATION OF PENICILLIN THERAPY IN ACUTE HEMATOGENOUS OSTEOMYELITIS *

BY W. A. ALTEMEIER, M.D., AND C. L WADSWORTH, M.D., CINCINNATI, OHIO

From the Department of Surgery of the University of Cincinnati College of Medicine and the Cincinnati General Hospital

The remarkable effectiveness of penicillin in the management of acute hematogenous osteomyelitis has been proved by clinical experience during the past four years. Florey's prophesy in 1943 has been fulfilled in the studies of Altemeier and his associates, McAdam, Aird, Higley and Rude, Hamilton and Boyd, Agerholm and Trueta; Hudson, Butler, Bodian, and others [14]; and Compere, Schnute, and Cattell. The spectacular control of the bacteriaemia, local infection, and metastatic complications by penicillin has produced profound changes in the course of this disease and a radical reduction in morbidity and mortality.

During the past four years, the authors have studied seventy-one cases of acute hematogenous osteomyelitis treated with penicillin, including sixty-seven cases involving one or more of the major long bones and four involving the flat bones of the pelvis (Table I). There was septic involvement of the adjacent joints in thirteen instances, the knee joint being involved in six, the hip joint in six, and the ankle in one. More than one bone was infected in thirteen of the seventy-one cases.

TABLE I

INCIDENCE OF ACUTE HEMATOGENOUS OSTEOMYELITIS IN THE VARIOUS BONES *

Bone Involved	Number of Cases
Femur	29
Tibia	26
Humerus	13
Fibula	3
Ulna	2
Radius	1
Ilium	3
Ischium	1

* Only the major bones involved are listed here minor bones, such as ribs and carpal bones, are not tabulated.

Fifty-six of these patients were treated in the Cincinnati General Hospital and the Children's Hospital, and the remainder were treated at the Christ Hospital, Good Samaritan Hospital, and Bethesda Hospital, located in or near Cincinnati. Included by permission are nine cases of other Cincinnati surgeons. In forty-seven cases, or 66 per cent., the individuals were ten years of age or younger; and in sixty-three cases, or approximately 90 per cent., the individuals were twenty years of age or less. Fifty-five (77 per cent.) of the patients were males and sixteen were females. The portals of entry of the hematogenous infection were furuncles in fourteen cases, infected abrasions of the skin in ten, infections of the upper-respiratory tract in ten, suppurative otitis media in three, infected teeth in two, and gingivitis, prostatitis, chicken pox, and scarlet fever each in one case. The distributing focus was unknown in 28 or 40 per cent. of the cases.

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 28, 1947.

TABLE II

INCIDENCE OF VARIOUS ETIOLOGICAL AGENTS
IN SEVENTY-ONE CASES OF ACUTE HEMATOGENOUS OSTEOMYELITIS

Type of Bacteria	Cases (No.)	Cases (Per cent.*)
Staphylococcus aureus	42	82.3
Non-hemolytic streptococcus	4	7.8
Hemolytic streptococcus	2	3.9
Pneumococcus, Type III	1	1.9
Green streptococcus	1	1.9
Gram-positive cocci	1	1 9
Undetermined	20	

* Based on fifty-one cases in which the infecting bacteria was determined.

Septicaemia was demonstrated in twenty-five or 35 per cent. of the patients by blood culture; the hemolytic *Staphylococcus aureus* was the infecting agent in twenty-one cases; the non-hemolytic *Staphylococcus aureus* in two, a green streptococcus in one, and a Type III pneumococcus in one. The responsible etiological agent was determined in 70 per cent. of the patients by culture, either of the blood or of material from the local infection. In the great majority of instances, the hemolytic *Staphylococcus aureus* (Table II) was responsible.

The administration of penicillin was regarded as the primary treatment in each case, and every effort was made to observe its full effect before any change was instituted in the therapeutic regime, although it was not always possible to do this. Sodium penicillin in aqueous solution was used in all but three cases; calcium penicillin was used in one; and penicillin in beeswax and oil was given in the remaining two. The highest single dose of sodium penicillin used was 50,000 units, and the lowest was 5,000 units. The doses most frequently given were 15,000 or 25,000 units. The intervals between injections were usually two or three hours, and the average duration of treatment was slightly more than nineteen days, the longest period of treatment being ninety-six days and the shortest seventeen hours in the patient who died seventeen and one-half hours after admission. In the early part of the study, the intravenous route was used most frequently; in the latter part, the intramuscular route. In seven instances the penicillin was given intravenously by continuous drip.

No significant variation in the seasonal incidence of acute hematogenous osteomyelitis was observed in this series (Table III).

The total amount of penicillin administered in each case is shown in Table IV. As the authors' experience increased, the dosage was also increased.

In five cases, very small soft-tissue abscesses were aspirated every two or more days

TABLE III

SEASONAL INCIDENCE OF ACUTE HEMATOGENOUS OSTEOMYELITIS

Months	Cases (No.)	Cases (Per cent.)
December, January, and February	19	26.8
March, April, and May	12	16.9
June, July, and August	19	26.8
September, October, and November	21	29.5
Totals	71	100.0

TABLE IV

TOTAL DOSAGES OF PENICILLIN USED

Dosages of Penicillin (*Units*)	Number of Cases
Less than 1,000,000	17
1,000,000 to 1,500,000	9
1,500,000 to 2,000,000	10
2,000,000 to 3,000,000	13
3,000,000 to 4,000,000	8
4,000,000 to 5,000,000	6
5,000,000 or more	8
Total	71

with syringe and needle; the cavity was partially refilled with a solution of penicillin containing 5,000 units per cubic centimeter, an average of 25,000 units being used each time after the aspiration of pus. Emergency surgical decompression of the infected area in the bone was not done in any instance. The presence of large or moderately large abscesses of the soft tissues was considered to be an indication for incision and drainage of the abscess, without drilling or other opening of the infected bone. This was carried out in nine cases before the onset of penicillin therapy, and in fifteen cases after its start. The affected extremity was immobilized by plaster mold or bivalved cast in thirty-eight of the patients. It was considered most essential in those with marked bone damage or in those in whom extensive demineralization of the involved areas developed.

The clinical response was noted with respect to the severity of the disease, the duration of the infection before the onset of penicillin treatment, the type and progression of changes occurring in the bone, the morbidity, and the mortality. An intensive follow-up has also been made in an effort to learn whether or not the beneficial effects of penicillin were lasting.

RESULTS

The immediate results of penicillin therapy in this series of cases were striking. All but one of the seventy-one patients recovered; in the one exception, a severe and neglected case of acute hematogenous osteomyelitis of the tibia with staphylococcal septicaemia and pneumonia, the patient was admitted to the Hospital in a moribund condition, seventeen and one-half hours before death. The mortality rate was remarkably low, therefore, being only 1.4 per cent. The reduction in the period of morbidity was also remarkable, particularly in those cases diagnosed early and treated adequately. In addition, the return to

TABLE V

CLASSIFICATION OF RESULTS IN SEVENTY-ONE CASES OF ACUTE HEMATOGENOUS OSTEOMYELITIS

Duration of Disease before Penicillin Treatment	No. of Cases	Results			
		Excellent	Good	Questionable	Failure
1 to 3 days (Group I)	14	8	4	2	0
4 to 6 days (Group II)	22	17	5	0	0
7 to 9 days (Group III)	15	4	10	1	0
10 days or more (Group IV)	20	2	15	2	1

TABLE VI

RELATIVE EFFECTIVENESS OF THE VARIOUS TOTAL DOSAGES OF PENICILLIN

Total Dosage of Penicillin (*Units*)	No. of Cases Treated	Cases with Excellent or Good Results (*No.*)	Cases with Excellent or Good Results (*Per cent.*)
Less than 1,000,000	17	14	82.4
1,000,000 to 1,500,000	9	8	88.8
1,500,000 to 2,000,000	10	10	100.0
2,000,000 to 3,000,000	13	12	92.3
3,000,000 to 4,000,000	8	8	100.0
4,000,000 to 5,000,000	6	6	100.0
More than 5,000,000	8	7	87.5

function of the extremity was much more rapid than with previous forms of treatment, normal weight-bearing often being permitted within three months.

It was difficult to assess the value of an antibiotic in a disease, such as acute hematogenous osteomyelitis, with both generalized and local manifestations of infection. In some instances of advanced hematogenous osteomyelitis with bacteriaemia, penicillin therapy made the blood stream sterile, seemed to arrest the local infection, and greatly decreased the period of morbidity; yet the disease had already produced extensive damage to the bone.

In general, the results of penicillin therapy seemed to vary primarily with the duration of the disease at the time the treatment was begun, with the dosage used, and with the severity of the individual infection. For purposes of discussion, the cases have been divided

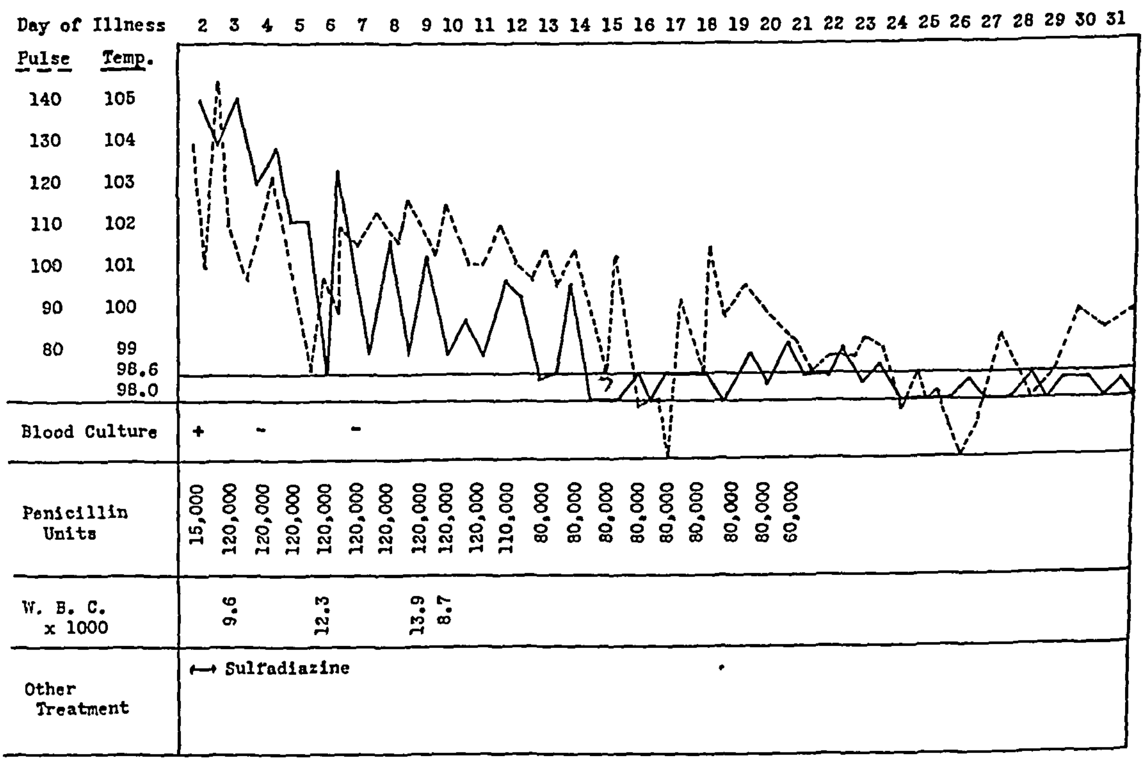

FIG. 1-A

Case 34. Showing the excellent results obtained with penicillin and conservative management in a case of acute hematogenous osteomyelitis of the right tibia with hemolytic *Staphylococcus aureus* septicaemia in a boy, aged eleven years. Rapid control of infection is manifested by sterilization of the blood stream, rapid fall of the temperature by lysis within ten or eleven days, absence of metastatic complications, return of the white blood count to a normal level, and disappearance of local signs. This was a Group II case.

Fig. 1-B

Fig. 1-C

Fig. 1-D

Fig. 1-E

Fig. 1-F

Fig. 1-G

Illustrating the spontaneous resolution of the area of osteomyelitis, resulting in complete healing with minimal residual damage and without sequestration, osteosclerosis, joint limitation, or abnormality of joint growth.

Fig. 1-B: Nov. 13, 1944. No demonstrable bone involvement or periosteal reaction.

Fig. 1-C: Nov. 28, 1944. Very early periosteal reaction on medial aspect of lower portion of tibia, and bone rarefaction in lower end of tibia.

Fig. 1-D: Dec. 16, 1944. Layering of the periosteum on medial aspect of tibia and extremely early reaction of periosteum on lateral aspect. Rarefaction in shaft of tibia is localized at a point about five centimeters above the epiphysis.

Fig. 1-E: Jan. 13, 1945. Area of rarefaction more pronounced. The periosteal reaction is much the same.

Fig. 1-F: Feb. 23, 1945. Periosteal reaction is slightly more pronounced, particularly on the medial aspect. Recalcification of the previously described area of demineralization is occurring.

Fig. 1-G: July 16, 1945. Recalcification and reconstitution of the involved area is complete. No evidence of active infection; minimal sclerosis of bone is seen.

Fig. 1-H

Fig. 1-H: May 16, 1947. The normal architecture of the bone has been re-established with no evidence of active infection, sequestration, or sclerosis.

FIG. 2-A FIG. 2-B FIG. 2-C FIG. 2-D FIG. 2-E

FIG. 2-F FIG. 2-G

Case 31. Illustrating the good results obtained with penicillin and conservative management in a Group II case of acute hematogenous osteomyelitis of the left tibia and right femur with hemolytic *Staphylococcus aureus* septicaemia and pneumonia in a boy, aged thirteen. Spontaneous resolution has occurred, but the progression of bone changes is slower and the degree of demineralization is greater. Nevertheless, ultimate healing appears to be complete.

Fig. 2-A: Oct. 26, 1943. Small area of rarefaction is shown on the lateral aspect of the tibia, just above the ankle, with a very thin break in the cortex. No periosteal reaction on medial aspect, in lower third.

Fig. 2-B: Nov. 17, 1943. Shows mottling of lower fourth of tibia, due to irregular and patchy areas of rarefaction. Very slight periosteal reaction on medial aspect, in lower third.

Fig. 2-C: Jan. 4, 1944. The mottling has increased in lower portion of tibia, and periosteal reaction is now well defined. A slight periosteal reaction is also present on lateral aspect of fibula, in distal fourth.

Fig. 2-D: Mar. 31, 1944. Shows more extensive bone rarefaction and periosteal reaction than on previous roentgenogram. Several breaks in tibial cortex are now easily seen.

Fig. 2-E: June 2, 1944. Less mottling is present than previously, and almost complete disappearance of the periosteal reaction. Recalcification is occurring. No sequestration is present.

Fig. 2-F: Sept. 1, 1944. Further recalcification and reconstruction of the involved bone is occurring.

Fig. 2-G: May 2, 1947. Recalcification and reconstitution of the bone is complete, with minimal sclerosis of bone. No evidence of sequestration or of continuing infection is seen. All mottling has disappeared, and no periosteal reaction remains. The healing of the infection appears complete.

arbitrarily into four groups: Group I consisted of those in which treatment with penicillin was started within three days of the onset of the first symptoms; Group II, those in which penicillin therapy was started within four to six days after onset; Group III, those in which treatment was instituted within seven to nine days; and Group IV, those in which the illness had existed for more than ten days before the start of penicillin therapy.

An arbitrary classification of the results was made on the basis of essential criteria established for each type (Table V). An *excellent* result was one in which evidence of complete and rapid control of the general and local manifestations of the infection began within seventy-two hours after the institution of penicillin therapy, and was fairly complete within ten days. Spontaneous resolution of the process followed, including complete healing of the infected bone with minimum residual damage and without sequestration, osteosclerosis, joint limitation, or residual abnormality of bone growth. Surgery was either unnecessary or it was limited to simple drainage of soft-tissue abscesses (Figs. 1-A to 1-H, inclusive).

In a *good* result there was a more gradual control of the general and local manifestations; this began within two to nine days after penicillin therapy was started, and was

Illustration of a good result obtained with penicillin and conservative management in an eight-year-old boy (Group IV case). The extensiveness and intensity of the roentgenographic changes are greater, but the process of healing has been completed with minimal residual damage.

Fig. 3-A: Mar. 31, 1944 Shows mottling at upper end of shaft of humerus and very slight periosteal reaction on lateral aspect of upper fourth of shaft

Fig. 3-B: Apr. 8, 1944. Mottling has continued down the shaft, to junction of upper and middle thirds. Periosteal reaction is present on both sides of shaft.

Fig. 3-C: Apr. 12, 1944 There has been marked increase in periosteal reaction, particularly on the lateral aspect of the shaft.

FIG. 3-A FIG. 3-B FIG. 3-C

FIG. 3-D FIG. 3-E FIG. 3-F FIG. 3-G

Fig. 3-D: Apr. 18, 1944. Marked increase in periosteal reaction is shown. Very small sequestrum seen under periosteum on lateral aspect.

Fig. 3-E: Apr. 27, 1944. Periosteal reaction and patchy demineralization have increased. There is a long narrow sequestrum on lateral aspect of shaft.

Fig. 3-F: June 22, 1944. Shows marked recalcification and moderate osteosclerosis. The sequestrum apparently is involved in the process of healing.

Fig. 3-G: May 16, 1947. Shows complete reconstruction of the humerus, with only minimal residual thickening of the cortex on the lateral aspect of the shaft. The excessive calcification has disappeared and much of the normal architecture of the bone has been re-established.

omplete within three weeks. Spontaneous resolution occurred more slowly, and complete ealing of the infected area was followed by minimal or moderate residual bone damage,

TABLE VII

NUMBER AND TYPE OF RECURRENT INFECTIONS

Case No.	Group No.	Total Dosage of Penicillin (*Units*)	Duration of Penicillin Therapy (*Days*)	Interval between Penicillin Therapy and Recurrence	Type of Recurrence
1	I	2,080,000	25	3 months	Sequestration with abscess
3	I	2,270,000	20	16 months	Cellulitis
9	IV	1,155,000	26	4 months	Sequestration with abscess
22	I	885,000	44	39 months	Cellulitis
26	I	840,000	7	8 months	Cellulitis
30	I	635,000	9	1 month	Relapse
35	IV	525,000	15	12 months	Sequestration Septic absorption of head of femur
43	III	6,600,000	12	1 month	Sequestration with abscess
47	III	650,000	4	2 weeks	Relapse

in association with one or more of the following: abscess formation, sequestration, osteosclerosis, joint limitation, and abnormality of bone growth. Surgery was either unnecessary or was limited to more elective surgical procedures, such as simple drainage of soft-tissue

FIG. 4-A FIG. 4-B FIG. 4-C

Demonstration of a questionable result in a Group I case of acute hematogenous osteomyelitis of the left tibia with hemolytic *Staphylococcus aureus* septicaemia, in a boy of seventeen years. Although penicillin controlled the generalized and invasive qualities of the infection, sequestration occurred, and the local infection remained active until treated by saucerization and sequestrectomy.

Fig. 4-A: Aug. 3, 1944. No evidence of bone or periosteal reaction is apparent.

Fig. 4-B: Aug. 17, 1944. There is periosteal reaction about the upper third of the tibial shaft. Very slight demineralization of the upper third of tibia is occurring.

Fig. 4-C: Nov. 10, 1944. There is slight increase in the amount of periosteal reaction about the upper end of the tibia and patchy demineralization of the upper end of the shaft, with increased sclerosis of the bone.

abscesses; removal of detached sequestra, or, in one instance, by saucerization of previously necrosed bone (Figs. 2-A to 3-G, inclusive).

A *questionable* result was one in which there was indefinite evidence of control of the general or local infection by penicillin. Surgery was not obviated in this group (Figs. 4-A to 5-F, inclusive).

A *poor* result was characterized by the failure of penicillin to control the infection, which resulted either in death or in continuation of the infectious destruction of the bone.

The number of excellent results was greatest in the first two groups, in which the diagnosis was made and penicillin therapy was started before the disease had progressed more than six days. The number of excellent results decreased sharply in the third and fourth groups, in which the diagnosis and treatment were delayed for seven or more days (Fig. 6). Nevertheless, the great majority of results were good, even in Groups III and IV.

One of the questionable results in Group I occurred in a patient in whom the dosage of 840,000 units of penicillin over a seven-day period was grossly inadequate by our present standards. Subsequent experience has indicated that 2,000,000 or 3,000,000 units, or more, over a period of at least twenty-one days, is a more effective dosage. The other questionable response in Group I occurred in a seventeen-year-old white male who was admitted to the Cincinnati General Hospital with acute hematogenous osteomyelitis of the left tibia and staphylococcal septicaemia. He was treated adequately with penicillin, and a long leg cast was applied. After his discharge from the Hospital, thirty-four days following the onset of therapy, he walked about on his cast. The cast cracked just below the knee, over the involved area of the tibia, and an ulceration was produced at this point. A draining sinus developed, and the subsequent roentgenographic findings of progressive local infection are illustrated in Figures 4-A to 4-F, inclusive. Experience has indicated that

Fig. 4-D Fig. 4-E Fig. 4-F

Fig. 4-D: Dec. 18, 1945. Shows definite sclerosis and thickening of the upper portion of the shaft of the tibia, with several large areas of decreased density in this region. A large sequestrum is visible near the lower end of the thickened portion.

Fig. 4-E: Apr. 10, 1946. The areas of sclerosis about the upper end of the tibia and several large irregular areas of decreased density persist. A small sequestrum is seen in the distal portion of the involved area.

Fig. 4-F: Oct. 15, 1946. The three areas of decreased density persist. The distal area shows smooth margins; the previously reported sequestrum has been removed. There is evidence of further progression of the chronic osteomyelitic process in the proximal two areas, which show irregular margins and a sequestrum in the superior one. A linear area of sclerosis is noted, extending downward from the mid-posterior region of the tibial shaft.

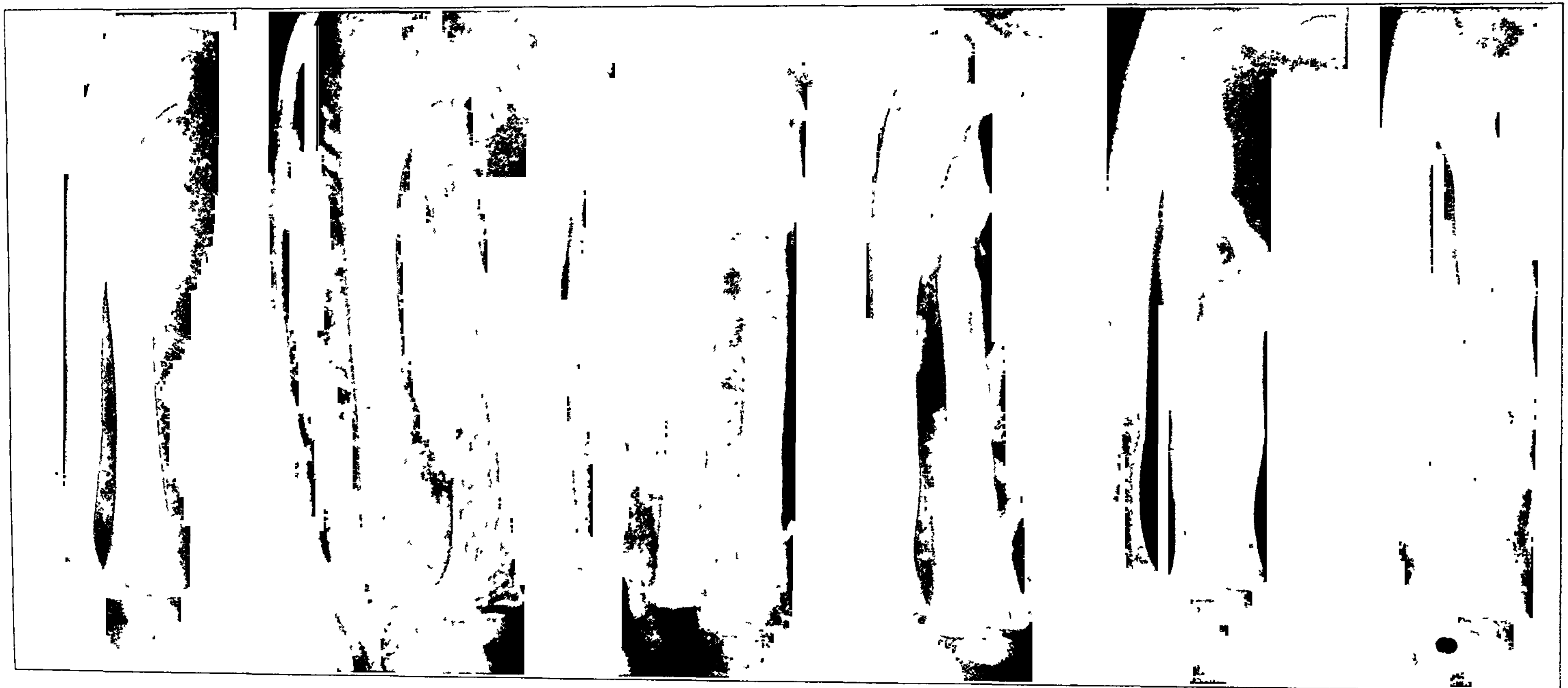

FIG. 5-A FIG. 5-B FIG. 5-C FIG. 5-D FIG. 5-E FIG. 5-F

Questionable result with sequestration and recurrent abscesses in a case of acute hematogenous *osteomyelitis* of the radius, not treated with penicillin until twenty-three days after the onset of the disease.

Fig. 5-A: June 20, 1944. Shows rarefaction at distal end of radius, probably early osteomyelitis.

Fig. 5-B: June 29, 1944. Rarefaction has extended upward through distal half of radius and also involves the proximal fourth. Several breaks have occurred in the cortex. Periosteal reaction is present, especially in proximal end.

Fig. 5-C: July 8, 1944. Shows increased periosteal reaction, with extensive demineralization of both ends of the radius.

Fig. 5-D: July 15, 1944. Very extensive periosteal reaction has occurred, with absorption of both ends of the shaft and beginning sequestration of the middle third.

Fig. 5-E: Oct. 27, 1944. The sequestrum, representing the middle third of the radial shaft, has been partially absorbed and apparently partially revitalized. Healing is progressing.

Fig. 5-F: July 5, 1946. Shows further reconstruction of the radius. A small sequestrum remains within an area of decreased density, near the junction of the upper and middle thirds.

immobilization and prohibition of active weight-bearing are important. In Group III, the questionable result obtained was one in which there was no consistent and continued attack on the infection with penicillin, although the amount of penicillin administered should have been adequate.

Two questionable results occurred in Group IV. In one, sequestration, pyarthrosis, and dislocation of the right hip developed in a patient whose treatment was neglected for nineteen days after the onset of infection. This patient was treated inadequately, with only 525,000 units of penicillin, following incision and drainage of a large abscess.

One failure occurred in a severe and neglected case of acute hematogenous osteomyelitis of the tibia of fourteen days' duration with overwhelming staphylococcal septicaemia and diffuse bilateral pneumonia.

When the results were compared with the total dosage of penicillin administered (Table VI), it was noted that the number of excellent and good results was greatest with dosages of more than 1,500,000 units.

Complete follow-up information was obtained in sixty-seven, or 94.4 per cent., of the cases. Nine recurrences have occurred to date (Table VII). This table reveals recurrences in five cases in Group I, in which the diagnosis was made and treatment was started within three days after the onset of the illness. This was disappointing, but is probably explained in three of the five cases by the inadequate doses of penicillin given over relatively short periods of time. In a fourth case, the patient walked regularly on his cast within one month after the onset of his infection (Figs. 4-A to 4-F, inclusive). There were no recurrences in Group II, where the cases were treated more energetically with penicillin, effective immobilization, and longer periods of non-weight-bearing. There were two recurrences in Group III.—Case 47, which was treated inadequately with 650,000 units, and Case 43, in which large doses of penicillin were given during the day for twelve days, but not at night. A relapse occurred within one month after cessation of therapy in two cases, and this has been attributed directly to inadequate amounts of penicillin.

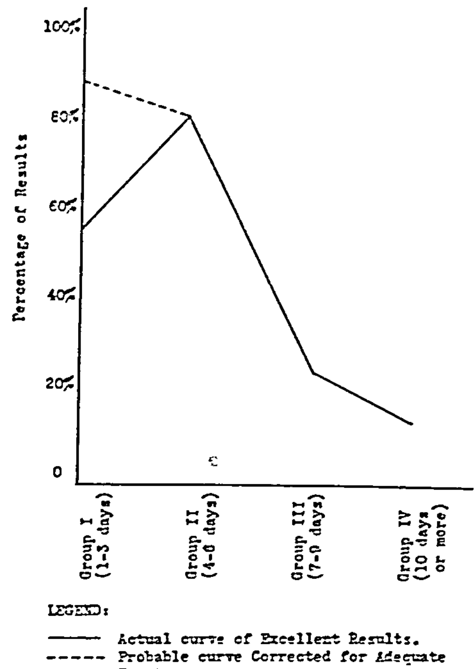

FIG. 6

Shows the percentage of excellent results, according to the duration of the disease before the start of penicillin treatment.

We were surprised to find only two instances of recurrence in Group IV, since the infection unquestionably went unchallenged long enough to produce extensive damage to the bone and soft tissues. In Case 9, sequestration had occurred before the diagnosis was made; and treatment, with a total of 1,155,000 units over a period of twenty-six days, was started on the twenty-third day of the disease. In Case 35, the diagnosis and treatment were delayed for nineteen days when extensive necrosis of the upper end of the femur and the femoral head became apparent. Treatment of this case consisted of incision and drainage of an abscess and an inadequate total dosage of penicillin (525,000 units over a fifteen-day period).

DISCUSSION

Since the principal bacterial agents of acute hematogenous osteomyelitis—the hemolytic staphylococcus, hemolytic streptococcus, non-hemolytic streptococcus, and pneumo-

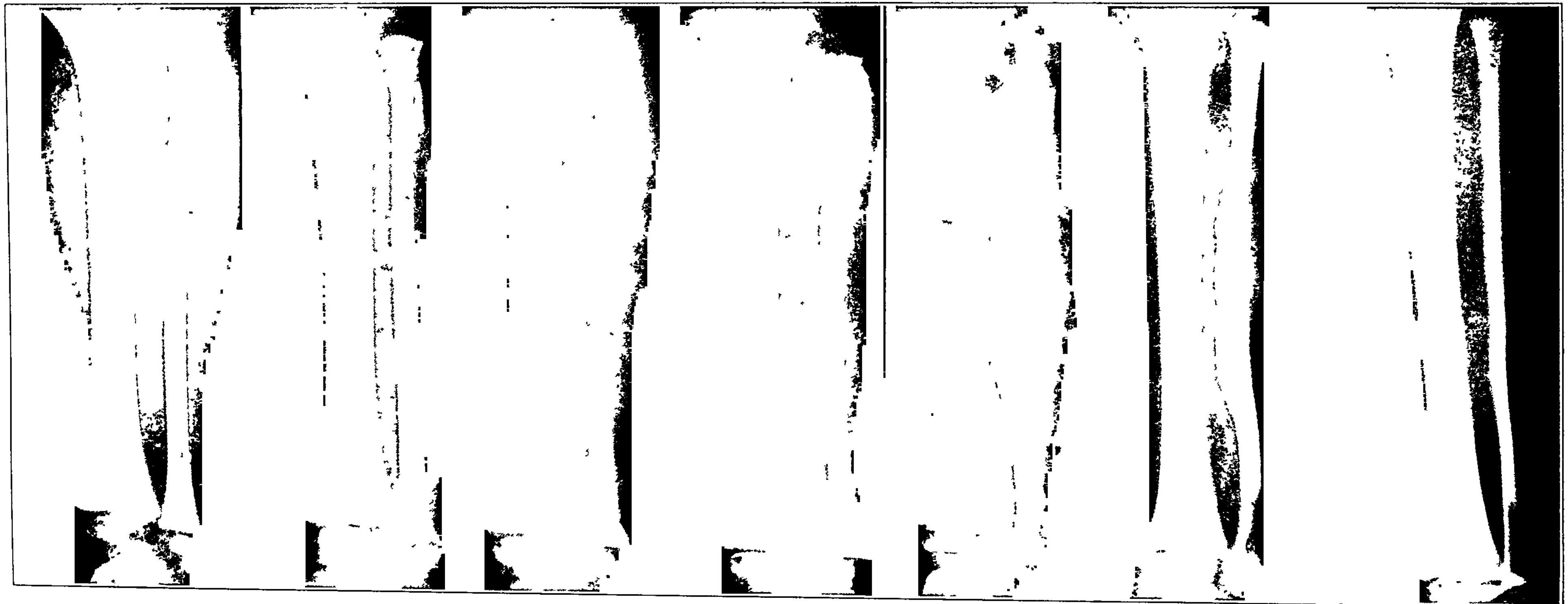

Fig. 7-A Fig. 7-B Fig. 7-C Fig. 7-D Fig. 7-E Fig. 7-F Fig. 7-G

Case 30. Relapse of infection occurred promptly after cessation of treatment with an inadequate amount of penicillin over a nine-day period, in a Group I case of acute hematogenous osteomyelitis of the fibula. The patient was a boy, aged thirteen months. Sequestration occurred, but the final result after further penicillin therapy was good.

Fig. 7-A: Oct. 23, 1943. No definite roentgenographic findings in bone or periosteum. Marked soft-tissue swelling was present.

Fig. 7-B: Nov. 4, 1943. Rarefaction may be seen at proximal and distal ends of fibula, with associated periosteal reaction. An area of periosteal reaction is also present at level of junction of middle and lower thirds.

Fig. 7-C: Nov. 25, 1943. Bone destruction involves lower two thirds of fibula, with absorption of proximal end. Marked periosteal reaction is seen in these areas. Practically two thirds of shaft is sequestrating.

Fig. 7-D: Jan. 18, 1944. Marked periosteal reaction is shown along entire shaft of fibula. The sequestrum has been partially absorbed.

Fig. 7-E: Apr. 24, 1944. Fibular shaft is being reformed by new bone, associated with the periosteal reaction. A long thin sequestrum which has undergone further absorption remains on the lateral portion of the fibula in its middle third.

Fig. 7-F: Sept. 8, 1944. Sequestrum has been previously removed. The healing process has produced reconstruction of fibula, with moderate irregularity and sclerosis of its middle third.

Fig. 7-G: June 5, 1947. Healing process is apparently complete, with straightening of fibula and marked decrease in sclerosis of this bone. Moderate thickening of cortex remains. Growth of bone has been normal.

FIG. 8-A FIG. 8-B FIG. 8-C FIG. 8-D FIG. 8-E FIG. 8-F

Spontaneous fracture occurring through demineralized area of humerus, two and one-half months after onset of the disease, in absence of immobilization.

Fig. 8-A: Aug. 18, 1944. No evidence of bone or periosteal involvement is seen.

Fig. 8-B: Aug. 30, 1944. Shows very slight demineralization at the proximal end of the shaft, but no definite evidence of osteomyelitis.

Fig. 8-C: Sept. 14, 1944. Shows extensive demineralization of the upper half of the humerus with considerable periosteal reaction. There is involvement of the epiphysis and the lateral portion of the head of the humerus. A questionable sequestrum is seen, near the lateral border of the upper third of the humerus.

Fig. 8-D: Oct. 30, 1944. Partial reconstruction of the upper half of the humerus has occurred, and the sequestrum is being absorbed. There is an irregularly transverse fracture, several centimeters above the condyles, and mottled areas of decreased density in the lower half of the shaft.

Fig. 8-E: Jan. 20, 1945. Reconstruction of the upper half of the humerus has occurred, but extensive destruction is seen in the lower portion of the shaft, above the fracture.

Fig. 8-F: May 9, 1947. The fracture has healed, and reconstruction of the humerus has occurred, with bowing and moderate osteosclerosis.

coccus—are sensitive to the action of penicillin, it is not surprising that this antibiotic has had such a profound effect upon the disease in its earlier stages, before extensive thrombosis of the nutrient vessels or stripping of the periosteum has occurred.

In the past, the mortality rate from acute hematogenous osteomyelitis was approximately 25 per cent., being 10 to 15 per cent. in the milder cases and often 50 per cent. or higher in the septicaemic or pyaemic varieties [8,12]. Sterilization of the blood stream and progressive control of the generalized infection by penicillin have reduced the mortality to 1.4 per cent. in this series. This reduction corresponds to that in other reports.

The prevention of metastatic or secondary infectious complications and the arrest of the local infectious process in bone have resulted in a decreased morbidity. If the metastatic complications, such as staphylococcal pneumonitis, pleuritis, pericarditis, or thrombophlebitis, already existed, penicillin was a powerful aid in their control, as an adjunct to surgical or conservative treatment. The usual period of hospitalization in the majority of cases was between twenty-five and thirty-five days.

Since the greatest number of excellent results were obtained in those cases diagnosed and treated during the first six days of illness, the urgent responsibility of the family physician is readily apparent. An early diagnosis in acute hematogenous osteomyelitis must be made on clinical grounds alone in order that penicillin therapy may be started at the time when it will do the most good. The dictum [6] that no roentgenographic diagnosis can be made until at least the seventh to tenth day of the disease, and often later, cannot be overemphasized. After the diagnosis has been made, the patient should be moved to a hospital immediately for intensive penicillin therapy. If there is any question as to the presence of acute osteomyelitis, it is recommended that penicillin be started at once and continued until the diagnosis has been established.

The evidence suggests that penicillin should be administered in adequate doses, at intervals of not more than three hours, for at least twenty successive days, until all clinical signs of infection have been absent for at least seven days. The dosage was increased as the authors' experience and the supply of the antibiotic agent increased.

No obvious clinical improvement may be apparent for seventy-two or more hours after the onset of penicillin therapy in patients treated without surgery. If a sharp fall in temperature and marked clinical improvement do not occur within this time, a careful search should be made for complicating or metastatic infections. The earliest clinical evidence of effectiveness was often the patient's feeling of improvement.

During the first four to ten or more days of the disease, the roentgenograms were of no practical value in detecting the nature of the disease process. Later, a succession of roentgenographic changes occurred, usually after the cessation of chemotherapy. Periosteal reaction, patchy areas of progressive demineralization of the involved bone, and breaks in the adjacent cortex were early signs which usually became evident ten to fourteen or more days after the onset of the illness, and reached their maximum extent and degree in one to five months. As the decalcification proceeded, the trabeculae often became ill-defined and irregular, suggesting permanent disorganization of the bone structure. The absence of an associated dense involucrum exaggerated the rarefaction of the shaft.

Demineralization appears to be a necessary step in the healing process of infected bone, but its true nature still is conjectural. Its increase with the severity and duration of the infection suggested that it represents absorption of bone previously necrosed by the infection. However, the later re-establishment of a normal or nearly normal architecture of the bone, with complete recalcification and minimal osteosclerosis, indicated that the lamellae are left more or less intact. In general, the reconstitution of bone seemed to occur with less resultant bone sclerosis than that seen with previous forms of treatment. The evidence suggests that adequate and early penicillin therapy arrested and controlled the local infection to such an extent that spontaneous absorption of the necrosed bone and repair by the process of recalcification were made possible.

It has been impressive to see the extensive degree of involvement, one to four months after the onset of treatment, and then to watch the process of spontaneous healing. When adjacent joints were involved, penicillin aided greatly in the control of the acute infection and decreased the degree of functional impairment. In nine instances, there was no residual impairment in function; while in four other cases—two of the hip, one of the ankle, and one of the elbow—continued impairment of joint function was noted.

Although sequestration was relatively uncommon in the cases treated with penicillin, it tended to occur late in the illness if the infection was unusually severe, if the diagnosis was delayed, or if treatment was late or inadequate. In this series, sequestration occurred in six cases. Experience thus far indicates that further conservative therapy is indicated when sequestration develops in conjunction with penicillin therapy.

There seems to be little doubt that early and adequate penicillin therapy made unnecessary the use of surgery for emergency decompression of the infected bone, in the great majority of instances, during the period when the patient was often desperately ill with a generalized infection. Instead, penicillin control of the infection also permitted correction of the altered physiology and adequate treatment of the metastatic complications. When abscesses developed, surgical drainage was done more safely and more effectively at a time when the patient was in a better condition, under the protective screen of parenterally administered penicillin. In addition, the cosmetic effects in the cases treated with penicillin were in sharp contrast to those in cases treated by other methods.

The long-term curative effects of penicillin in acute hematogenous osteomyelitis are still undetermined. However, recurrences have developed in nine instances, usually when treatment was late, inadequate, or not sustained.

On the basis of an analysis of our experiences thus far, the following plan of management is recommended:

1. *Establishment of the Diagnosis at the Earliest Possible Time:* Recognition of the disease must be on the basis of clinical signs and symptoms, without help from the roentgen ray, at the time when penicillin therapy can be expected to give excellent results in the majority of instances. One must be thoroughly familiar with the clinical picture, therefore, as well as with the differential diagnosis. In case of doubt, it is recommended that adequate penicillin therapy be started immediately and continued until a definite diagnosis has been made.

2. *Early and Adequate Penicillin Therapy:* As soon as the diagnosis has been made, a dose of at least 20,000 units of penicillin should be given intramuscularly or intravenously, and repeated every two or three hours for at least seven days after the signs of infection are well under control. In severe infections, doses of 50,000 to 100,000 units may be given at the same interval until a clinical response has been obtained. A total dosage of at least 2,000,000 or 3,000,000 units, administered over a period of three or more weeks, seems to be adequate in most instances, but in case of incomplete response of the infection, penicillin should be continued. Its dose may be revised upward in infections produced by more resistant strains of bacteria. Obviously, it is not indicated in acute hematogenous osteomyelitis caused by gram-negative or other penicillin-resistant bacteria.

3. *Surgery:* Emergency surgical intervention is usually unnecessary, and conservative surgical procedures may be postponed until the infection has been controlled and the alterations in physiology have been corrected. Large soft-tissue abscesses, present at the start of treatment or developing during treatment, should be incised and drained early in order to release the necrotizing toxins, thereby lessening the toxaemia and local necrosis. We have not resutured these wounds either immediately or within five to seven days, as practised by the British surgeons under the protective screen of penicillin therapy, but have left the wounds open, being as careful as possible to protect the wound and avoid secondary contamination. Very small abscesses may be treated by repeated aspiration and instillation of a solution of penicillin containing 5,000 units per cubic centimeter. If

sequestration occurs, further conservative treatment is advised, while the fate of th sequestrum is followed by serial roentgenograms. In case of incomplete absorption, detach ment from the adjacent bone, or involvement in an abscess cavity, sequestrectomy i indicated.

4. *Immobilization:* During the acute phase of the infection, immobilization of th involved area is recommended for at least three weeks, preferably by a plaster splint o bivalved plaster cast, to permit frequent inspections of the involved area for progressio or regression of the signs of local infection. Further immobilization is indicated in a instances in which decalcification and rarefaction of the bone become considerable, sinc failure to protect the weakened bone may result in spontaneous fracture.

5. *Active Weight-Bearing:* Active weight-bearing should be delayed for at least thre months in the cases showing the best response to therapy, and longer, as indicated, i those with more extensive damage to bone.

6. *Adequate Supportive Therapy:* Adequate supportive therapy with repeated smal blood transfusions, fluids, electrolytes, and oxygen is indicated to correct the alteration in physiology and to overcome the effects of the infection.

7. *Continued Vigilance:* Vigilance is necessary to determine the progress and exten of the disease, as well as to detect the development of soft-tissue abscesses, metastati visceral complications, or purulent arthritis of contiguous joints. If the infection shoulc become fulminating, emergency surgical drainage must be instituted as early as possible

8. *Serial Roentgenographic Examinations:* Serial roentgenograms are recommended at intervals of one week during the early stages of the disease, and at intervals of one month during the later phases, for at least one year, to determine the extent of damage to the bone, the development of sequestra, the involvement of adjacent joints, and the degree of osteosclerosis.

SUMMARY

A study of seventy-one cases of acute hematogenous osteomyelitis, made during the past four years, has indicated that penicillin is a powerful and effective antibiotic in this disease. This finding has not only radically changed our ideas concerning the most satisfactory methods of management, but has altered our interpretation of the significance of some of the roentgenographic changes occurring during the course of the disease. When administered early and adequately, penicillin reduced mortality and morbidity, controlled the infection, minimized local destruction of the bone and resultant deformities, permitted spontaneous absorption of the involved bone, healing, and early return of normal or nearly normal function. Follow-up studies indicated that healing of the bone has been very satisfactory in the great majority of instances, with restoration of its architecture to normal or near normal and with considerably less osteosclerosis, sequestration, and impairment of function of the adjacent joints. The number of recurrences has been low, and limited almost entirely to those cases in which the amount of penicillin administered was too small, the duration of treatment too short, the intervals between injections too long, the beginning of treatment seven or more days after the onset of the disease, or the use of immobilization absent or inadequate.

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ACUTE HEMATOGENOUS OSTEOMYELITIS

A STUDY OF TREATMENT *†

BY I. WILLIAM NACHLAS, M.D., AND HERBERT R. MARKHEIM, M.D., BALTIMORE, MARYLAND

The subject of treatment for acute hematogenous osteomyelitis is, at the present time, a controversial one. The form of treatment that had come to be generally accepted was based on the concept that the lesion in the bone constituted a local infection and demanded early incision and drainage. Recently, however, this method has been challenged. The relatively high mortality or the long period of recovery that follows such treatment has caused investigators to look for other methods. The concept evolved that the patient with osteomyelitis is suffering primarily from a systemic infection, a bacteriaemia, of which the bone involvement is only a local manifestation. Under this principle, attention must be directed toward the patient as a whole, with a primary attack against the bacteriaemia. Modifications have also been made in the treatment of the bone lesion.

The older procedure consists in treatment "by operation as soon as the condition is recognized. . . . *it is extremely important to operate early, particularly within the first twenty-four to forty-eight hours.* . . ." [1] This treatment was based on the hypothesis that, unless early drainage could be supplied, the developing abscess, with its increasing pressure within the rigid, bony confines, would spread bacterial fluids over a broader area,—possibly even forcing them into the blood stream. Consequently, there could be expected (a) increased local bone damage, with a resultant longer period of illness; (b) a new focus for bacteriaemia, with a threat of increased mortality; and (c) a larger number of metastatic abscesses. Because of these possibilities, early drainage was considered so important

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 28, 1947.

† The expenses for this study were met by a grant from the Sydney M. Cone Research Foundation, Inc.

TABLE I

MORTALITY

Group	No. of Patients	Deaths (No.)	Deaths (Per cent.)
Emergency surgery	78	7	9
Delayed surgery	32	1	3
Chemotherapy	20	0	0
Total or average	130	8	6

that bone drilling was advised if an osteomyelitic abscess was even suspected. A clea osteotomy, it was explained, would do no harm; whereas a delay in operating upon a bon abscess could produce serious results.

By contrast, the advocates of the systemic form of treatment advance the concep that acute hematogenous osteomyelitis is basically a bacteriaemia, in which the depositio of organisms in the bone may lead to local infection. Based on this belief, systemic anti bacterial treatment becomes the important primary step. If the bone lesion has not ye developed sufficiently to block the circulation, the chemotherapeutic agent can reach th impending abscess and sterilize it. Surgical trauma to the bone, because of its interferenc with the blood flow and because of the formation of local thromboses, is not a benig procedure, and should be avoided in the acute stage of the disease. Indeed, "clean' osteotomies may be considered a plowing of the soil, that will facilitate the implantatio of blood-borne organisms and the development of a local abscess. Furthermore, sinc staphylococci are the usual bacterial offenders, and since these organisms are slow i causing a local protective barrier or a systemic immunological response to develop, earl tampering with an abscess is likely to spread the organisms and should, therefore, b avoided.

Thus we find two schools of thought and two radically different methods of treatment. In spite of the fact that, in the recent literature, one finds many articles reporting series of cases treated satisfactorily by the systemic approach, there are many excellent surgeons who claim that treatment by emergency surgery gives better results. The accuracy of this statement can be determined by a comparative statistical survey.

With this in mind, the authors have collected and critically analyzed the records of patients with acute hematogenous osteomyelitis seen by them during the ten-year period from 1936 through 1945. In determining the proper case histories to be included in this series, several criteria were used. Only patients with the hematogenous variety of osteomyelitis, who had presented themselves in the acute stage of the disease, were chosen. As proof of the diagnosis, the presence of a positive culture from the operative field or the characteristic roentgenographic changes in the bone were considered necessary.

In twenty-five instances, a presumptive diagnosis of osteomyelitis had been made on the basis of the classical local and systemic signs, including positive blood cultures; the patients had been treated by antibiotics, but had recovered without the development

TABLE II

AVERAGE DURATION OF DISEASE

Group	No. of Patients	Duration (Days)
Emergency surgery	53	714
Delayed surgery	18	360
Chemotherapy	20	169
Total	91	

of positive roentgenographic signs. These cases were not included in the present series because of the unproved diagnosis, but they must be borne in mind in the general evaluations.

After sifting the cases, with these restrictions in mind, 130 patients were found who met the requirements. Although a few had had both surgery and chemotherapy in the course of their hospital stay, the patients, as a whole, can be separated on the basis of the pattern of their treatment into a chemotherapy group and a surgery group. The surgery group can be further divided into those patients who had emergency operations—that is, within twenty-four to forty-eight hours after admission—and those whose operations were delayed for five days or more after hospital admission. Thus there are three classifications:

Emergency surgery	78 patients
Delayed surgery	32 patients
Chemotherapy	20 patients

In these categories, comparisons were made with regard to (1) mortality, (2) duration of the disease, (3) recurrences, and (4) metastatic bone lesions.

1. *Mortality*

The fatalities in this series numbered eight, or 6.1 per cent., of the total. All of these deaths occurred among patients in the surgery group; seven of them had been treated by emergency surgery and one by delayed surgery. There were no deaths in the group treated by chemotherapy alone. Thus, the death rate for each group is as follows: Emergency Surgery showed 9 per cent., Delayed Surgery 3 per cent., and Chemotherapy 0 (Table I).

2. *Duration of Disease*

In obtaining the figures reported, the patient's bone lesion was considered as active from the date of onset of the local symptoms until the time of closure of the wound, or, in those instances where there was no open wound, the time when the patient was discharged as recovered. Since a number of patients had left our immediate care before their sinuses or wounds had closed, the date of cessation of drainage was obtained from a questionnaire sent to each patient. The answers were accepted as accurate, but reports for final analysis were collected from only ninety-one, or 70 per cent., of the total number of patients. On the basis of these figures, the average duration of the disease was found to be 714 days for the fifty-three patients of the Emergency Surgery group, 360 days for the eighteen patients of the Delayed Surgery group, and 169 days for the twenty patients in the Chemotherapy group (Table II).

3. *Recurrences*

Under this heading, only those patients were included in whom a local infection developed after closure of the wound. It was found that 40 per cent. of the patients (twenty-one of fifty-three) treated by emergency surgery, 22 per cent. of the patients (four of eighteen) treated by delayed surgery, and 10 per cent of the patients (two of twenty) treated by chemotherapy showed recurrences (Table III).

4. *Metastatic Bone Lesions*

When a patient was admitted, the focus or foci of infection were noted. Any additional foci that developed later were considered, for the purposes of this study, metastatic. By again dividing the patients into three groups, it was observed that there were metastatic abscesses in 23 per cent. of those treated by emergency surgery (twelve of fifty-three), 22 per cent. of those treated by delayed surgery (four of eighteen), and 10 per cent. of those treated by chemotherapy (two of twenty) (Table IV).

TABLE III

RECURRENCES

Group	No. of Patients	Recurrences (No.)	(Per cent.)
Emergency surgery	53	21	40
Delayed surgery	18	4	22
Chemotherapy	20	2	10
Totals	91	27	

TABLE IV

METASTATIC ABSCESSES

Group	No. of Patients	Metastatic Abscesses (No.)	(Per cent.)
Emergency surgery	53	12	23
Delayed surgery	18	4	22
Chemotherapy	20	2	10
Totals	91	18	

In some of the patients treated by the systemic technique, rather extensive roentgenographic changes were noted. It seemed desirable to make comparative studies of the roentgenograms; but, because most of the older films were not available for inspection, it was impossible to do this. Although this would have been an interesting addition to the study, it is not essential, since this is a study of end results, and the important statistics are covered by the phases enumerated.

ANALYSIS OF OBSERVATIONS

These figures are so startling, particularly with regard to mortality, that one is led to wonder if the more radical procedure, emergency incision and drainage, was used on the sicker patients, while the more conservative chemotherapeutic method was reserved for the less urgent cases. As far as can be determined from the records, no such differentiation was made. Certainly the twenty patients treated by the systemic approach were not subjected to this therapy because of the mildness of their illness, but rather because of the conviction of the surgeon. Fourteen of these patients had records of blood cultures, eleven of which were positive. In the eight fatal cases, only one patient seemed to be very ill on admission. Six of the remaining seven showed positive blood cultures. The Delayed Surgery group contained a number of patients who were so sick on admission that the nature of their illness was obscure. Indeed, the reason for delay was generally the need for further time to establish a diagnosis.

The figures enumerated lead to the following conclusions: The best results were obtained in patients who were treated by the systemic approach. Delay in instituting surgical drainage was proved not the dangerous practice we have believed it to be. On the contrary, the results were much better in this group than they were in those patients who had immediate incision and drainage. The most striking differences were noted in the distribution of the fatalities,—none in the Chemotherapy group, one in the Delayed Surgery group, and seven in the Emergency Surgery group.

Whatever may have been said of the theoretical arguments against immediate surgical intervention, the factual reports prompt us to accept the newer methods, particularly now that we have antibiotics.

The most important change in method is based on the idea that the treatment must

be directed toward the patient as a whole, rather than toward the osteomyelitic lesion. This sounds obvious, but emphasis on this concept leads to an alteration in the details of the treatment. It is still imperative that early diagnosis be made. It is even more urgent that systemic antibacterial measures be started immediately. Indeed, this is so important that such treatment should be instituted before the corroborative diagnostic tests have all been completed. One may expect from this that a fair percentage of the potential bone infections will be aborted. The bactericides will also serve as an excellent controlling medium, preventing expansion of the infection and protecting the patient against the spread of bacteria through the blood stream.

If a definite abscess is recognized, it is desirable that surgery be delayed until the autogenous protective mechanism and barriers have been set up, and until the bacteriaemia has cleared. At that time, surgery may be indicated for the institution of drainage. The trauma of the operative procedure should be limited to the confines of the protective barrier. When the abscess is small, or when bone damage is recognized by roentgenogram only, it is possible that surgery may be avoided. However, some of these small abscesses enlarge slowly as months go by, and careful surgical judgment must be exercised to determine the need for incision and drainage Certainly a number of bones that showed considerable structural change by roentgenogram demonstrated the ability to readjust themselves without surgical interference.

Our knowledge of the techniques and characteristics of chemotherapy has improved over the years. It is not always enough to administer antibiotics only until the fever has subsided; one must continue their administration for some time after the systemic manifestations have been overcome. In two patients, treated before this procedure was adopted, it was observed that the osteomyelitis became active again upon early withdrawal of the drugs, and a new intensive period of medication was required before the infection was eradicated. More recent studies with chemotherapeutic agents indicate that the organism may develop tolerance to these drugs. It appears desirable, therefore, to treat these patients with massive doses, and to prolong the treatment for seven to ten days after all clinical signs of the disease have receded. It is further deemed necessary to keep the patient under careful observation for several months after this period.

The institution of therapeutic procedures before the nature of the disease has been established may offend the academic instincts of those who require a diagnosis before beginning treatment, but the time element is so important that we are justified in mobilizing our defensive forces at the first threat of an invasion. The undesirable effects of such treatment are negligible, while experience with the twenty-five healed cases excluded from this series warrants the anticipation that many osteomyelitic lesions may be aborted. It is believed that, as surgeons become indoctrinated with this method, scientific justification will follow in the form of a statistical demonstration of the reduced incidence of hematogenous osteomyelitis.

1. Phemister, D. B.: Pyogenic Osteomyelitis, p. 727F. *In* Orthopedic Surgery, edited by R. K. Ghormley New York, Thomas Nelson and Sons, 1938.

DISCUSSION

Dr. Dallas B. Phemister, Chicago, Illinois: These excellent presentations have shown that penicillin therapy is actually revolutionizing the treatment of acute pyogenic osteomyelitis; but the same does not hold for the cases that are inadequately treated during the acute stage and have become chronic. There, bone surgery must be combined with penicillin therapy, in order to get satisfactory results. When the initiation of penicillin treatment is delayed until after extensive necrosis of bone has occurred, the dead bone may be rendered so sterile that it undergoes creeping replacement by new bone, not unlike that which takes place in a sterile bone graft or bone infarct. This was shown by Dr. Altemeier to be true for children. That it may occur in adults is illustrated by the following two cases:

In one case of severe staphylococcic osteomyelitis of the femur in a soldier, twenty-seven years old, massive penicillin therapy was started seven days after the onset of infection and was continued for five weeks. Extensive necrosis of the cortex in the course of about five and one-half weeks revealed evidence of

absorption of an intensively necrotic ten inches of the shaft, with beginning sequestration and involucrum formation. Roentgenograms, four and one-half months later, showed marked absorption of the dead bone and an extensive involucrum. Seven and one-half months later, nearly all the dead bone had been absorbed; and at nine and one-half months the new-bone formation was almost complete. One year from the onset, all of the dead bone had been removed and the shaft was so well formed that the repair could be considered complete.

The second case is that of a thirty-year-old woman who had an acute pyogenic osteomyelitis, involving the head and upper four inches of the diaphysis of the left femur, and pyogenic arthritis of the hip joint. Sulfadiazine and penicillin treatment was not started until the sixth day, by which time there must have been extensive necrosis of bone in the head, neck, and shaft, extending to the subtrochanteric region. The treatment was continued for five weeks, after which it was resumed at irregular intervals for a period of ten months. The infection was overcome and healing was accomplished without abscess formation or operation. Two weeks after the start of the process, roentgenograms showed practically no signs of change in the bone or joint, but at the end of two months there were evidences of extensive necrotic bone in the head and neck and extensive absorption in the intertrochanteric and subtrochanteric regions of the shaft. Subsequent roentgenograms, during the course of fifteen months, showed gradual disappearance of all of the dead bone. That in the shaft and in most of the neck was replaced by new bone; but the upper portion of the neck and head, being free from any surrounding osteogenetic elements, and subject to stress and strain as it was invaded by new bone from below, broke off and was eroded and absorbed, with complete absence of any replacement by new bone. This was accomplished by healthy granulation tissue, acting on a sequestrum that had been sterilized by the penicillin and sulfonamide therapy. Had the dead head not been sterilized, it would not have been absorbed, and an operation would have been necessary for its removal.

Dr. Frank D. Dickson, Kansas City, Missouri: There can be no doubt but that penicillin influences favorably the course of infection in bone. If used early in the disease, it will control the infection in a high percentage of cases. Unfortunately, however, cases are often seen after a lapse of considerable time because an early diagnosis had not been made, and we are confronted with an abscess already present in the bone. In this type of case, early drainage is indicated and should be carried out. Our experience, both before and since the advent of antibiotics, has convinced us that early drainage in the majority of cases will shorten the course of the disease, will reduce to a minimum the amount of bone destruction, and is the greatest safeguard against later lighting up of foci which are quiescent but not necessarily cured and, therefore, potentially capable of becoming active again under favorable conditions.

Dr. Altemeier reported 12.6 per cent. of recurrences in sixty-seven cases followed as long as sixteen months after treatment with penicillin, but without drainage. Our experience suggests that this percentage will increase as time goes on, because latent infection can be present in bone and can be very difficult to determine by roentgenogram. There is no place for surgery, in my opinion, in the treatment of osteomyelitis in the presence of septicaemia and pyaemia with multiple abscess formation. In such cases we are dealing with a true septicaemia; the opening of a single bone abscess will serve no useful purpose, and may do actual harm. However, it is my opinion, based on long-established surgical principles, that drainage is indicated when a single abscess is present without septicaemia. It is still my thorough conviction that early drainage can be safely done, for, properly performed, it carries with it practically no surgical risk. It is difficult for me to understand why a simple procedure, which follows established surgical principles, should have so much opposition. Obviously, the treatment of osteomyelitis without the use of modern antibiotic agents should be obsolete, but failure to use proper surgical drainage in the presence of pus in bone is equally untenable.

Mr. H. J. Seddon, Oxford, England: It seems to me that we have three things to consider: first, the control of the systemic infection; second, the evacuation of an abscess, if present; and third, the prevention of secondary infection. In penicillin we have an almost perfect agent for controlling systemic infection. I agree with everything that Dr. Dickson has said about the need for evacuation of an abscess. If we examine pus from an abscess three or four days after intensive penicillin treatment has been started, it will be found to contain very lively staphylococci. The abscess is not sterilized; and, if it is left, the staphylococci will persist. Evacuation is not an urgent matter, but a decision for or against drainage should usually be made within two or three days of the institution of systemic penicillin treatment. The lesion may subside very rapidly; all pain and swelling may disappear within three days, and it is then safe to do nothing. If tenderness persists, incision is necessary. If, as is likely, a subperiosteal abscess is found, it is absolutely essential to drill the bone, for there is no other way of determining whether an intra-osseous abscess is present. A small drill should be used, and the first hole should be made in the bone at the metaphyseal end of the floor of the abscess cavity. Quite frequently, pus wells out when this first drill hole is made. Drilling is continued, in a line away from the metaphysis, until blood is tapped. There is no risk whatever of causing spread of infection, since the blood stream carries a protective concentration of penicillin.

There need be no hesitation in closing the wound, but, generally speaking, the skin alone should be sutured, and interrupted stitches are essential. If the wound is inspected after four days (which is unnecessary

and undesirable), it will be found to look like an incision made over the tibia for removal of a bone graft. This is, I believe, the complete answer to the bugbear of secondary infection.

These views are based on the work of my colleague, Trueta, who has treated all our cases of osteomyelitis between June 1944 and January 1947. There were fifty in all, and the results are as follows: There were no deaths, no amputations, no deformities, no joint infections developing after admission, no secondary foci developing after treatment had been started, no recurrences, and no pathological fracture or dislocation. In all but one case, the second in our series, function is perfect: that patient has limitation of knee flexion (0 to 90 degrees) and the femoral abscess was not drained. In forty-seven of the fifty cases (fifty-five foci), healing was sound. Sequestra developed in seven of the fifty-five infected bones.

Dr. A. W. Farmer, Toronto, Canada: The following data were given to me by Dr. R. Wilkinson, who has cared for these patients in recent years:

At the Hospital for Sick Children, Toronto, from 1923 to 1936, there were 674 cases of acute hematogenous osteomyelitis with 140 deaths, a mortality of 20.7 per cent. From January 1940 to June 1947 there have been 169 cases with 7 deaths, a mortality of 4.1 per cent.

Autopsies were done in the seven fatal cases. In all, death was due to septicaemia with multiple pyaemic abscesses. There have been no deaths since August 1944.

Since the spring of 1942, following the lead of our late Surgeon-in-Chief, Dr. D. E. Robertson, we have not been operating upon patients with acute haematogenous osteomyelitis at the Hospital for Sick Children.

We have been using penicillin routinely in osteomyelitis only since January 1945. From January 1945 to June 1947, there have been thirty-eight cases, twenty with positive blood cultures. Three of these have required sequestrectomy. One suffered a pathological fracture of the femur, which has united. In no case did secondary lesions develop while the patient was in the Hospital. There were no deaths and none of these patients has a sinus.

In conclusion, four observations have been made on this method of treatment:

1. The clinical course of these patients is better than it used to be.
2. There has been less death of bone.
3. Multiple foci are rare.
4. Mortality has been reduced from 20.7 per cent. to 4.1 per cent.

Dr. W. A. Altemeier (closing): I wish to thank the various discussors for their remarks and to emphasize several points.

A review of the literature indicates the marked effect of penicillin on the mortality rate from acute hematogenous osteomyelitis. Whether treatment consisted of the parenteral or intramedullary administration, the mortality has been reduced to less than 2.0 per cent. In our series it was 1.4 per cent. The decrease in morbidity was equally significant.

Definite abscesses, developing before or during therapy, should be incised surgically under the protective screen of systemic penicillin therapy, as soon as the condition of the patient permits. The abscess usually contains not only viable bacteria, but also necrotizing toxins, capable of producing further destruction to adjacent bone. Drilling of the metaphysis in the presence of a subperiosteal abscess has not been necessary, in our experience.

Although there have been nine recurrences in sixty-seven cases treated with penicillin, a definite reason has been apparent in all but two, this reason being either a delay in diagnosis and treatment until advanced destruction of bone had occurred, inadequate dosage, or faulty administration. The great majority of recurrences occurred in the group of patients whose treatment was delayed nineteen to twenty-three days and whose infection had produced both abscess formation and extensive damage to the bone. It does not seem logical that the drilling of holes through extensive areas of dead bone would make any significant difference in the ultimate roentgenographic changes.

Dr. I. William Nachlas (closing): I am grateful to the discussors for not making this picture sound one-sided. We do not have the complete answer yet; other factors enter the problem. Sterilization alone will not prevent avascular necrosis in an area that relies for its circulation on an end artery which has been blocked by thrombosis; but this is a separate problem. Our immediate question should be, "Which is the better technique for the treatment of acute osteomyelitis?" Our report would indicate that the more conservative procedure gives better results. It is to be hoped that improvement in technique, better antibiotics, and earlier diagnosis will yield even better results.

VERTEBRAL OSTEOTOMY

Technique, Indications, and Results

BY DOCTEUR J.-J. HERBERT, AIX-LES-BAINS, FRANCE

From the Rheumatism Center of Aix-les-Bains

The correction of deformity of the vertebral column in ankylosing spondylarthritis is relatively simple, provided the bony segments in the thoracolumbar region have not fused. In a series of observations recently recorded by the author, the correction has been obtained in a very satisfactory manner by simple orthopaedic means; but the problem is not the same when ankylosis is complete.

Let us recall that the deformity is a long thoracic and lumbar kyphosis, the head assuming the forward position. When there is bony ankylosis of the thoracic, lumbar, and sacral segments, it is evident that orthopaedic measures will be unsuccessful.

What is to be done? At first glance the problem appears simple. Correction of the deformity of the long bones can easily be accomplished by osteotomy. As for the vertebral column, it is necessary to do the same thing,—that is, an osteotomy. Unhappily, the comparison must end here, because the vertebral column contains within it the spinal cord and nerve roots.

The spinal cord is protected by two bony masses, constituting virtually two bony columns,—posteriorly, the spinous processes, flanked by the laminae and articular processes; in front, the vertebral bodies. In spondylarthritis of these two columns, there is fusion in an awkward position. In order to re-establish equilibrium, it suffices to make in succession two cuneiform osteotomies, the apices of which should be directed toward the vertebral canal, the bases away from it.

Few authors have interested themselves in the problem of vertebral-body osteotomy; for, while it is relatively easy to attack the elements of the neural arch from behind, the same is not true of the posterior approach to the vertebral bodies. Huc approached the vertebral bodies through the lumbar muscles. However, this is not practical; the vertebral bodies are deep, and the proximity of the lumbar plexus adds to the difficulties.

We have often noticed, during lumbar sympathectomy, the ease with which one can reach the vertebral bodies through the left lumbo-iliac incision, pushing forward and to the right the abdominal mass. It is by means of this approach that one should carry out the osteotomy of the vertebral body.

In short, vertebral osteotomy can be accomplished in two stages, at an interval of a fortnight or three weeks:

1. That of the neural arch, by the posterior approach;
2. That of the vertebral body, by the flank approach.

Smith-Petersen had the great merit of carrying out the first vertebral osteotomy, obtaining his corrections by osteotomy of the neural arches alone. After resection of two or three lumbar spinous processes, he sectioned the ligamentum flavum or, if this structure had ossified, he performed an osteotomy; he next osteotomized the articular processes at one or more levels. Correction was then accomplished and grafts, taken on the spot, were so placed as to favor ankylosis in the corrected position. The author believes, however, that the posterior osteotomy alone is insufficient in cases with a considerable degree of ossification of the anterior longitudinal ligament.

La Chapelle of Amsterdam has performed osteotomy on both neural arch and vertebral body, as described here. His patient's condition was one of spondylarthritis following trauma, with total bony ankylosis. La Chapelle operated in two stages, following a technique very near to that which will be described here.

TECHNIQUE

I. *First Stage: Osteotomy of the Neural Arch*

One commonly finds at operation, ossification of the interspinous and flaval ligaments. To have seen the masses of bone that have replaced the posterior articulations or interlaminal spaces is sufficient to realize how difficult it is to perform the osteotomy along the articular planes, as has been done by Smith-Petersen. It has been my practice to osteotomize the mass of bone representing the fused articular processes between the second and third lumbar vertebrae, as well as the bridge of bone often found between the laminae and spinous processes of these vertebrae. In this way the vertebral canal and the intervertebral foramina are opened. It is in the osteotomy of the fused posterior articulations, situated as they are immediately behind the intervertebral foramina, that one finds the key to successful intervention. The osteotomy is wedge-shaped or rather trapezoid, the apex being at the level of the intervertebral foramina and the base being formed by the two corresponding spinous processes.

The accomplishment of such an osteotomy is difficult, for in spondylarthritis, especially in the more advanced stages of evolution, the bone is prone to be as hard as ivory. One must proceed with the osteotome; the rongeur is powerless. To open the vertebral canal by this method necessitates considerable skill and the use of a good deal of force. An ill-directed blow of the hammer may result in penetration of the dura and the creation of lasting caudal or root lesions.

The operation is performed under a general anaesthetic; the patient, supported by pillows, lies prone.

The incision follows the mid-line and extends from the first to the fifth lumbar spinous processes; it is necessary to have a wide field of operation. Four spinous processes must be freed, one above and one below the two spinous processes at the site of osteotomy. The approach is subperiosteal and includes the articular processes of the second and third lumbar vertebrae. The reflection is continued farther laterally, until the transverse processes of the third lumbar are reached. It is also necessary to partially free the posterior articulations between the third and fourth lumbar vertebrae, as well as those between the first and second. An excellent view of the structures to be osteotomized is indispensable.

The structures between the third and fourth lumbar spinous processes are divided obliquely, the osteotome being directed anteriorly and cephalad, and penetrating to the laminae. At this point it is necessary to be very prudent, knowing how not to advance the edge of the osteotome more than a few millimeters at a time, so as not to brutally break into the vertebral canal. One proceeds in the same manner between the first and second lumbar spinous processes during the osteotomy, the osteotome being directed anteriorly and distally.

One then proceeds laterally to the outer edge of the fused articular processes between the second and third lumbar vertebrae, using the transverse processes of the third lumbar vertebra as a guide. It is necessary to employ a curved osteotome. The osteotome should be directed tangentially to the transverse processes. The posterior articulation is removed, little by little, by means of light taps of the hammer. The lever-like movements of the osteotomy tend to raise the intervening bone; finally it becomes detached. If the osteotomy has been well carried out, the vertebral canal and the two intervertebral foramina are found to be open at the completion of the osteotomy, and the spinal dura comes into view. Often, through fear of going too far, one leaves a little bony bridge behind the intervertebral foramina, which could easily have been removed with a thin rongeur.

Examination of the bony block removed at the osteotomy shows it to be composed of the second and third lumbar spinous processes with the more or less ossified intervening interspinal ligaments, the two corresponding pairs of laminae, and the posterior articulations between the second and third lumbar vertebrae. If there is no ankylosis of the

vertebral bodies, one can correct the deformity by removal of the wedge of bone created by the osteotomy. The correction is accomplished by raising the superior portion of the trunk, through the help of assistants. Sometimes a dry crack indicates rupture of the anterior common ligament at the level of the osteotomy, whereupon correction of the deformity follows. If there is bony ankylosis anteriorly, the straightening can be done only at the time of the second stage.

A fairly large opening of the vertebral canal and the two foramina is necessary. The laminectomy should measure about four centimeters from its upper to its lower limits, at the level of the tips of the spinous processes; at the intervertebral foramina it should be one centimeter. These dimensions vary with the degree of kyphosis. Following correction, the laminae should no longer come into contact, but the posterior walls of the intervertebral foramina should close. There should be vertebral support at the level of the osteotomy,—in front, by the contact of the posterior edges of the vertebral bodies adjacent to the osteotomy; at the back, by contact of the remnants of the neural arches at the posterior wall of the intervertebral foramina.

During the operation, one is struck by the slight amount of hemorrhage of the bone surfaces. Hemorrhage can be controlled with a little patience. It is well for cosmetic reasons to bevel the spinous processes of the vertebrae, above and below the osteotomy site.

Postoperative Care

The kyphotic position should at first be maintained by the support of pillows. Correction should be gradual, in order to avoid undue stretching of the nerves; gradually the

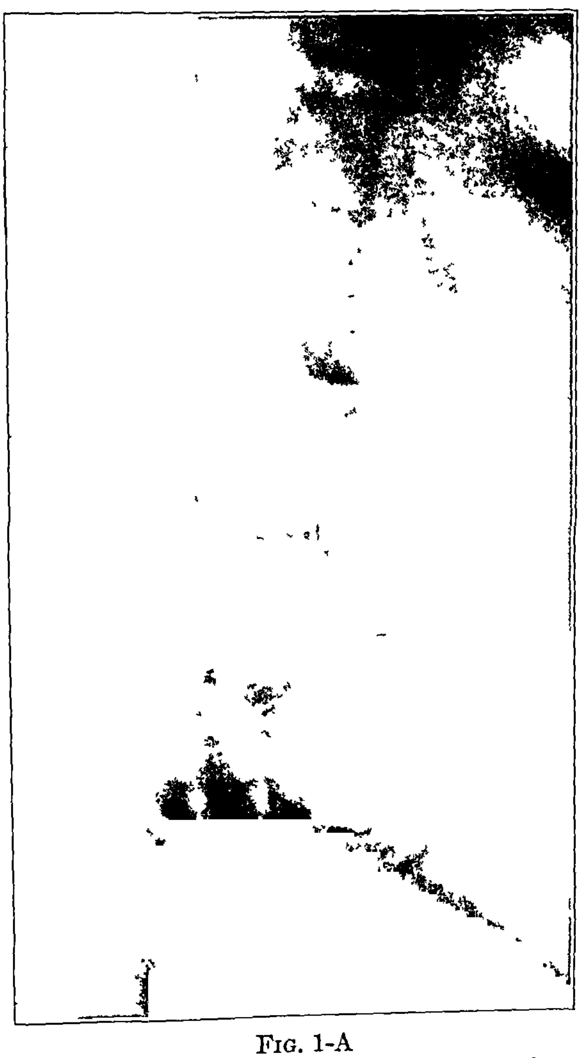


Fig. 1-A

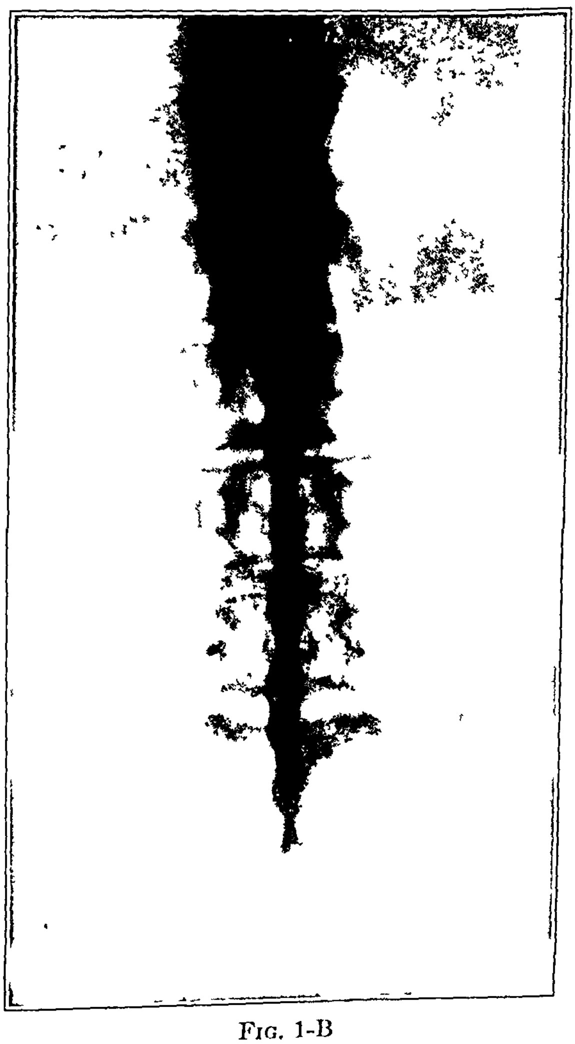


Fig. 1-B

Case 1. Lateral and anteroposterior views of spinal column before operation.

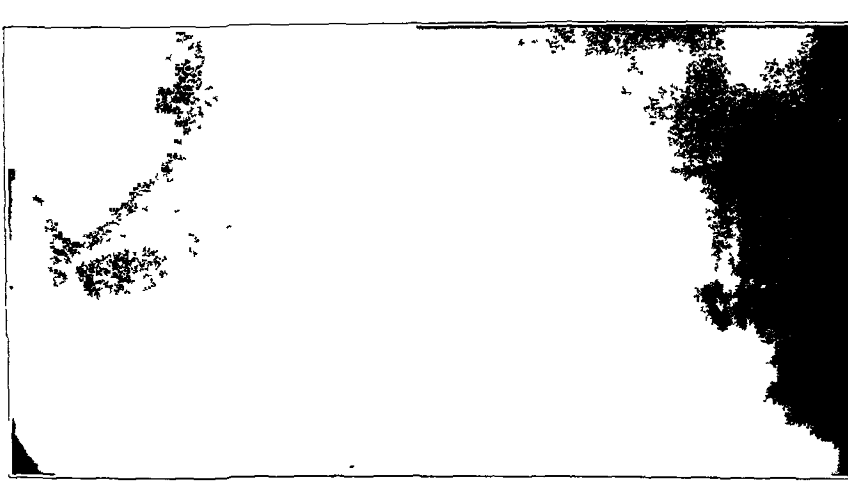


FIG. 1-C
Lateral view of spinal column after operation

FIG. 1-D
Anteroposterior view of spine after operation

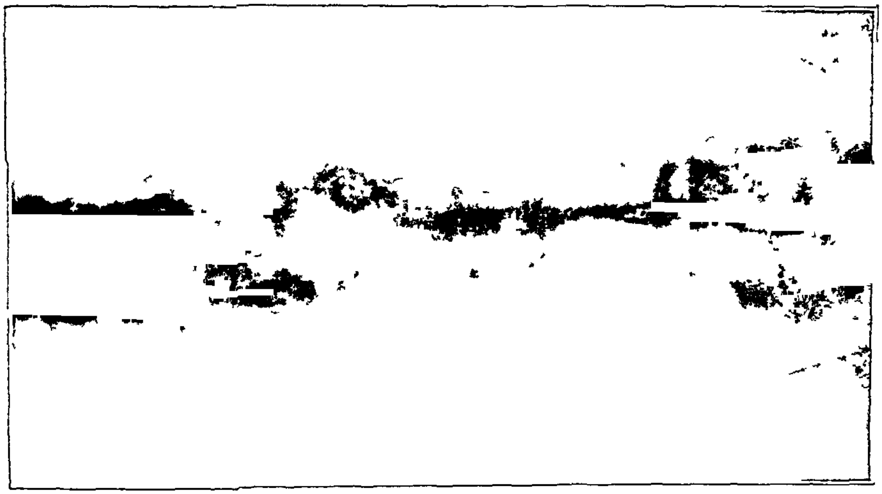


FIG. 1-E
Anteroposterior view, one year after operation.

supporting pillows are reduced. Acute pain may be experienced, especially in the area o distribution of the lateral cutaneous nerve of the thigh. This pain disappears in about te days. When correction is considered to be sufficient, a plaster jacket is applied.

If correction does not occur or is insufficient, a second operation becomes necessary

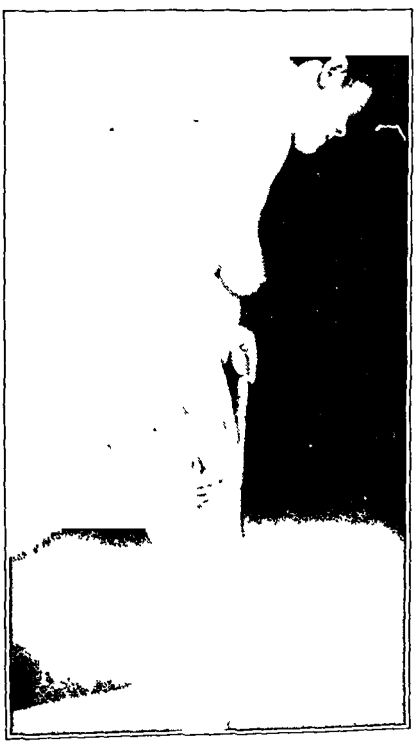
II. *Second Stage: Anterior Osteotomy*

It must be remembered that one of the characteristic lesions of ankylosing spondyl arthritis is the ossification of the anterior longitudinal ligament. This is often partial, in complete, and of varying density.

The operation consists in resection of the disc corresponding to the posterior oste otomy, followed by immediate reduction of the kyphosis and the introduction of a tibial graft between the osteotomized vertebrae. An alternative procedure is the transverse sectioning of the anterior longitudinal ligament at the level of several discs, followed by delayed reduction of the kyphosis. These two procedures may be used in combination.

Exposure

The patient is placed in the semi-supine position. A horizontal incision is made, from a point about five centimeters lateral to the umbilicus to the anterior border of the fascia about the lumbar erectors. The muscles are divided and the peritoneum exposed. The peritoneum is reflected from the posterior wall, and at the same time the abdominal viscera are retracted forward. It may be necessary to divide the eleventh and twelfth ribs, in order to enlarge the space between the thoracic border and the iliac crest, narrowed by the kyphosis. In one instance it was necessary to divide the ninth and tenth ribs, in addition, in order to obtain a satisfactory exposure. The vertebral bodies and intervertebral discs come well into view as the peritoneal reflection is continued toward the mid-line. During the vertebral exposure there may be considerable bleeding, especially along the upper psoas. The dissection is continued behind the aorta, which can be plainly seen. In controlling the hemorrhage, the use of clips is indispensable. The vertebral bodies are liberated subperiosteally with a sharp curved elevator.



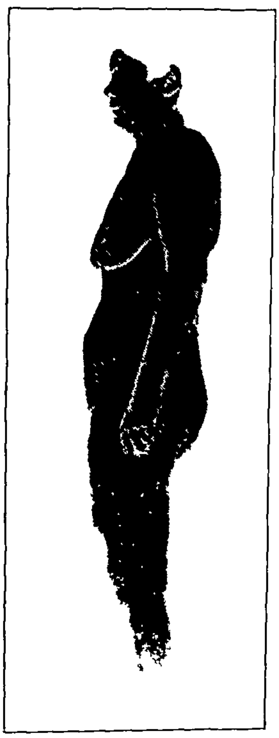


FIG. 1-F FIG. 1-G
Lateral views of patient, before and after operation.

It is relatively easy to expose the second, third, fourth, and fifth intervertebral discs. The first disc is practically inaccessible.

Vertebral Osteotomy

The disc may be resected, care being taken to avoid opening the vertebral canal. An alternative procedure consists in simple section of the anterior longitudinal ligament. Usually a scalpel suffices in either procedure, the osteotome being unnecessary. During the procedure, an assistant may move the vertebral column into extension, causing correction which can be seen at the site of resection of the disc.

If the use of an intervertebral graft is considered necessary, its dimensions are determined and a bed for it is prepared in the wedge-shaped intervertebral space. The

bone is removed from the tibia and carefully inserted across the resected intervertebral disc.

Hemostasis is then secured; this may be difficult. Following the closure of the wound, the patient is encased in a plaster jacket, applied on the operating table. An orthopaedic table is necessary, in order that the jacket may be applied at the time of surgery without moving the patient.

Following operation, there may be fairly acute pain in the region of the lower portion of the abdominal wall, the upper portion of the thigh, and the lateral aspect of the thigh, especially in the distribution of the lateral femoral cutaneous nerve. These pains may be experienced during a period of from eight to ten days. The pain may be eliminated by flexing the hip joints, thus demonstrating that it is due to nerve tension. In general, the patient becomes symptom-free after twelve days and can be ambulatory in two or three weeks, wearing, of course, his plaster jacket.

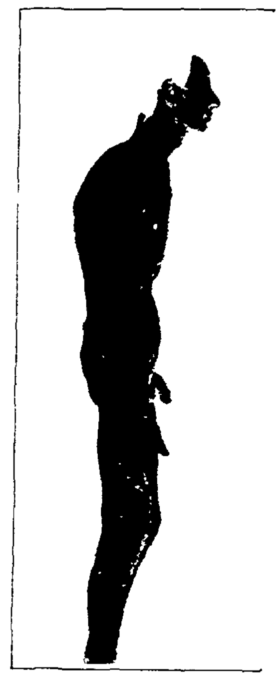


FIG. 2-A FIG. 2-B

Case 2. Lateral views of patient, before and after operation

INDICATIONS

From a theoretical viewpoint, this operation is good for all serious and correctable vertebral kyphoses. In practice, it is essentially for spondylarthritis with advanced ankylosis and kyphotic deformity. This is the only type of case included in this series.

It is necessary to operate at the optimum time. The opinion is commonly held that surgical intervention in cases of rheumatoid arthritis ought not to be undertaken during an active phase, but should await a time when there is lessening or absence of pain. Such a time is further indicated by a normal Verne reaction and the return of the sedimentation rate to normal. While such a view may be correct for polyarthritis, it is not applicable to spondylarthritis. This is also the opinion of Smith-Petersen. Deformity appears in spondylarthritis at a relatively advanced stage of evolution, often three to five years or more after the onset of the disease. If one wishes to await the cessation of activity, there may be a delay of ten years, the lesions during this time having become incurable, the intervention more difficult, and the result in the main less satisfactory.

In choosing the time to operate, it is more important to consider the general state of the patient than the degree of activity of the rheumatoid lesions. Often, however, the general and local conditions parallel one another.

The following policy is recommended in the management of spondylarthritis

1. Early mobilization as soon as the least deformity appears or as soon as pain becomes intense;

2. The correction of deformity, when it exists, and the maintenance of correction by non-operative orthopaedic means;

3. In the event of failure of correction by simple orthopaedic measures, the correction of deformity by vertebral osteotomy is indicated.

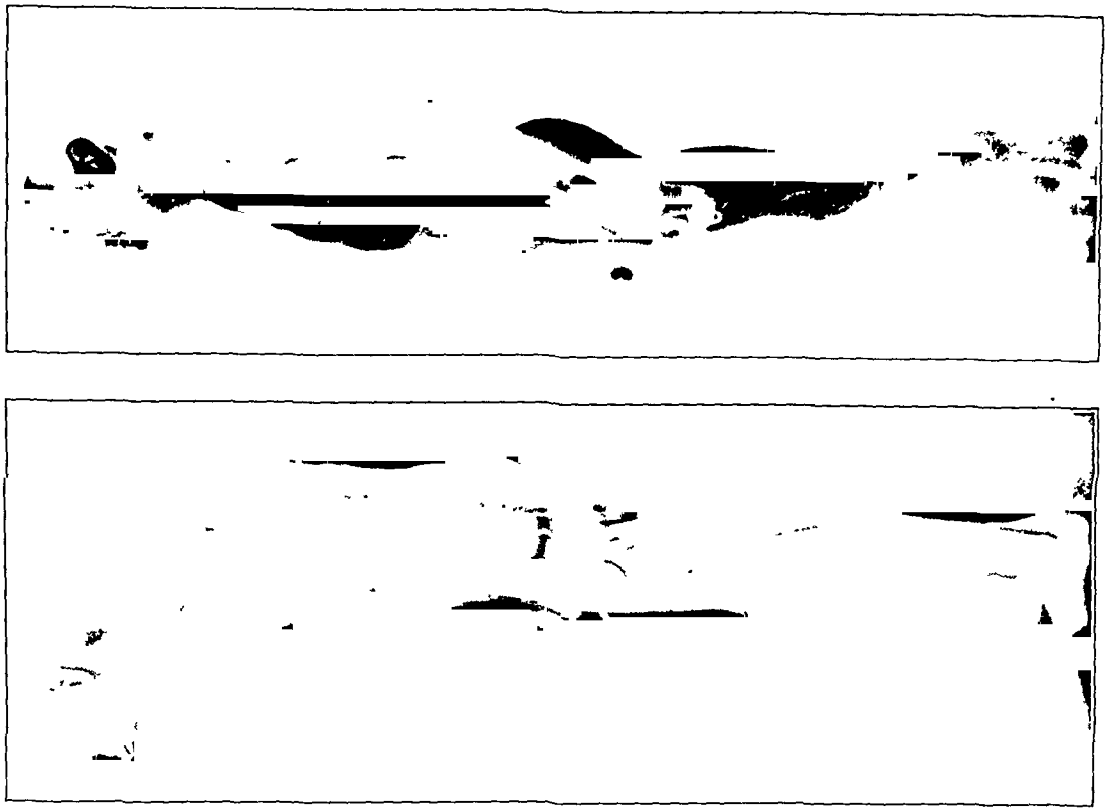


FIG. 3-C FIG. 3-D
Lateral views of patient, before and after operation.

FIG. 3-A FIG. 3-B
Case 3. Lateral views of spinal column, before and after operation.

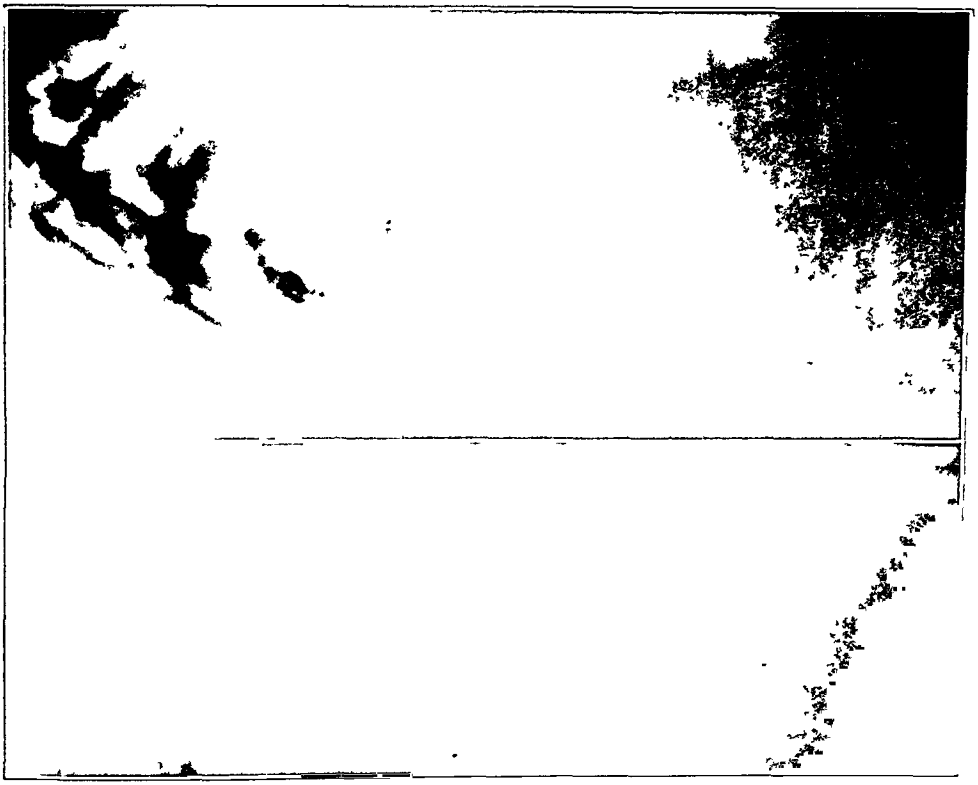


Fig. 1-B

Lateral views, before and after operation.

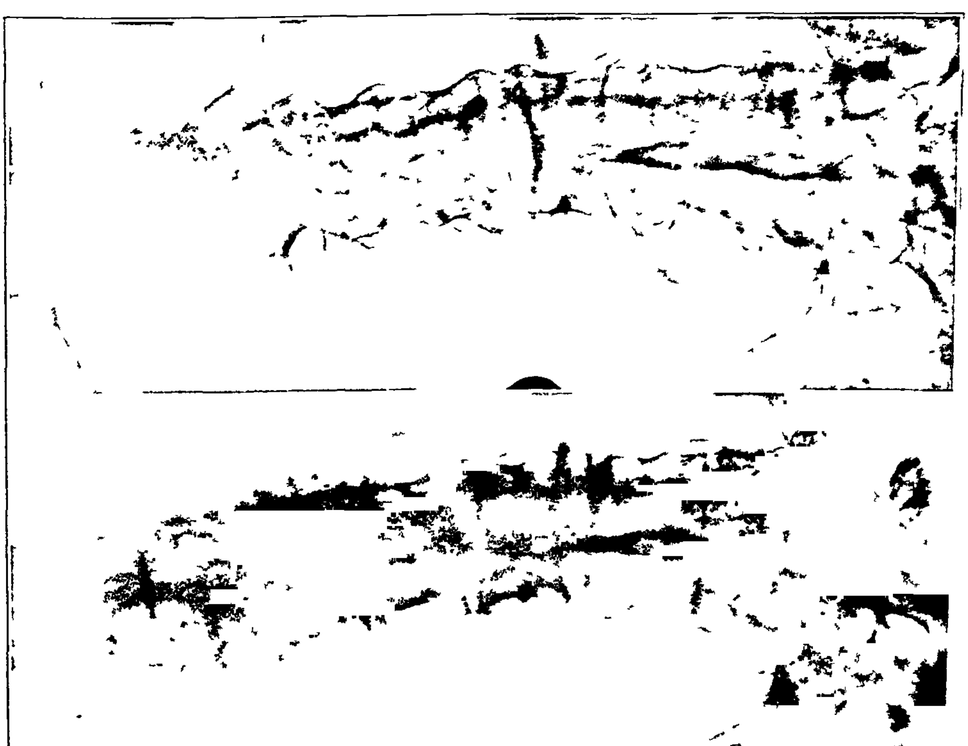


Fig. 1-A

Case 1. Anteroposterior views of the spinal column, before and after operation.

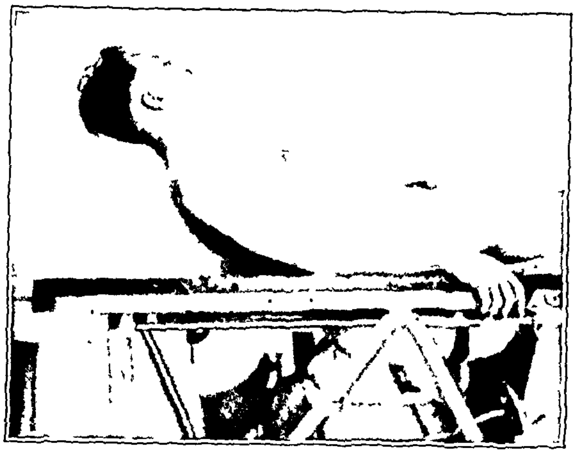


FIG. 4-C

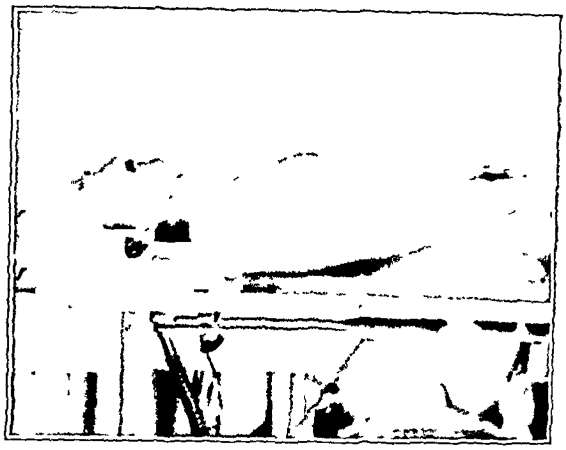


FIG. 4-D

Patient resting on table, before and after operation.

It is very evident that the orthopaedic treatment, both operative and non-operative, is only one of the elements in the therapy of this condition. Although the patient's deformity may be corrected, the disease remains, and the patient should submit to the discipline of medical treatment for a considerable period. Physical therapy should not be neglected. The ultimate success must depend upon the general state of the patient's health.

CASE REPORTS

CASE 1. In Mrs. B., thirty-seven years of age, spondylarthritis developed at the age of seventeen, but actual deformity was not noted until 1939, twenty years later. At the time of operation there was a pronounced thoracic and lumbar kyphosis; the head projected forward about thirty centimeters from the vertical. The roentgenogram revealed complete ankylosis of the posterior articulations, with ossification of the flaval and interspinal ligaments. The cervical segments of the column were normal.

On January 2, 1947, posterior osteotomy was performed at the level of the second lumbar intervertebral disc. Correction was immediate.

Following operation there was pain in the distribution of the lateral cutaneous nerve of the thigh. This subsided in a few weeks, and had disappeared by February 13. The patient became ambulatory at that time. Correction was almost complete. Early in May 1947, there was roentgenographic evidence of fusion at the level of the osteotomy. The patient was able to stoop and walk without pain or disability.

CASE 2. Mr. D., thirty-seven years of age, had had spondylarthritis for ten years. Deformity began in 1941. Actually there was a considerable thoracic and lumbar kyphosis. The patient could not look straight in front of him. The cervical column was involved. Roentgenograms showed ankylosis of the posterior articulations, as well as of the vertebral bodies. On January 15, 1947, an osteotomy opposite the first lumbar intervertebral disc was carried out. This proved insufficient to allow correction and, on January 31, the second-stage operation was performed; at this time the second, third, and fourth lumbar discs were sectioned. This sufficed to allow correction of the deformity on the operating table. Immediately the patient was placed in a plaster jacket.

During the following days, there was pain on the anterior and lateral aspects of the thighs, but this disappeared at the end of a few weeks. The patient became ambulatory after two weeks, and a month after operation he was able to make the journey from Aix-les-Bains to Paris, to be presented at the meeting of the Anti-Rheumatism League on March 13, at the Saint Antoine Hospital.

CASE 3. In Mr. M., thirty-six years of age, spondylarthritis developed in 1941, while he was a prisoner in Germany. Deformity was noted during 1943. There was general kyphosis, which included the cervical, thoracic, and lumbar regions, but which was especially marked in the upper thoracic region. The head projected forward from the vertical for a distance of about twenty centimeters. The entire column was fused, roentgenograms revealing ankylosis between the vertebral bodies as well as between the neural arches. On June 11, 1947, the posterior osteotomy was performed at the level of the third lumbar intervertebral disc. This operation did not accomplish correction and, on June 17, the anterior osteotomy was carried out at the level of the third lumbar disc. Correction was then obtained gradually and, by June 30, the patient could lie flat on a table with his head in the normal position. On July 5, a plaster jacket was applied, with anterior support of the Swain type. With this, the patient was able to walk comfortably for several kilometers.

CASE 4. In Mr. S., forty-two years of age, rheumatoid arthritis, with pain of sciatic distribution, developed in 1927. Marked deformity was noted in 1935, the trunk being fixed in the forward-bent position. The forward projection of the head from the vertical was about forty centimeters. Cervical movements were fairly free. The roentgenograms revealed ankylosis, both anteriorly and posteriorly, but there was no fusion at the level of the third lumbar intervertebral disc.

On August 1, 1947, the posterior osteotomy was performed at the level of the third lumbar disc. This operation alone was sufficient, for in a few days correction was obtained and, on August 6, the patient was able to lie flat on a table, supine, with the head in a normal position. A plaster jacket was applied on August 20, and the patient is now able to walk without pain.

To perform these operations, skill and prudence are needed. Hemostasis requires a good deal of attention.

The impressive thing in these cases has been the patient's mild reaction to extensive correction, following the formidable operative procedure. The test of correction is the ability of the patient to lie flat on his back on a hard surface, the posterior aspect of the lower extremities, the lower part of the back, and the back of the head coming into contact with the table. If the patient can assume this position, balance has been re-established in a very satisfactory manner.

The only postoperative complications encountered in this series have consisted of pain, due to tension upon the nerves, which is readily explained by the change of length resulting from the correction. This nerve-trunk tension occurs in the region of the lumbar plexus, particularly in the lateral cutaneous nerve of the thigh. It is of the utmost importance that great care be exercised during the gradual postoperative reduction of the deformity, to prevent undue pain from the stretching of nerves.

All of our patients who have been treated in the manner described have been relieved, not only physically but mentally.

NOTE: Since this preliminary report was submitted, anterior and posterior vertebral osteotomies have been performed on five additional patients, with the same satisfactory results as in the cases reported here.

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NORMAL FLEXIBILITY ACCORDING TO AGE GROUPS

BY HENRY O. KENDALL AND FLORENCE P. KENDALL, BALTIMORE, MARYLAND

WITH A FOREWORD BY GEORGE E. BENNETT, M.D., BALTIMORE

FOREWORD

Accurate data regarding the normal flexibility of the human spine at various ag levels are of extreme importance. Such data should constitute a guide in determinin whether individual inability to accomplish certain movements is normal or abnormal.

With the overemphasis on obtaining flexibility in much present-day treatment c poliomyelitic patients, we see increasing need for a guide as to what is "normal". Th study presented here affirms the fact that an abnormal degree of flexibility is produced b certain forms of treatment.

In patients affected by poliomyelitis and other diseases which produce muscle weak ness, stability rather than flexibility is of paramount importance in the end result. Sucl stability is essential in the spine, as well as in the extremities. In the presence of muscl weakness, one should be unusually cautious to avoid stretch of the underlying structures so that ligamentous and capsular support may help to compensate for loss of muscl support.

This study raises interesting questions in regard to the relationship between age-leve variations in flexibility and the age at which such conditions as epiphysitis and idiopathi scoliosis occur. One is inclined to ask what relationship strenuous flexion movements migh have to epiphyseal disturbances and compression or wedging of the vertebrae. The ad visability of certain physical-education activities, during the periods when flexion appear to be normally limited, should be considered carefully.

George E. Bennett, M.D

Touching finger tips to toes with knees straight is quite generally accepted as a "normal" accomplishment in physical examinations and in therapeutic-exercise procedures. That such a movement is not "normal" for all age groups was observed by the authors in testing individuals, and was substantiated by a preliminary study in 1943[2], in which muscle and posture tests were done on the entire student body at a girls' school. Approximately 300 girls were tested in this survey, but the total number was too small for a conclusive report. In January 1947, arrangements were made with Elmon L. Vernier, Ph.D., Director of Health and Physical Education, Baltimore City Department of Education, to have his staff of physical-education instructors test school children for certain flexibility movements. A total of 4,533 school children from kindergarten through the twelfth grade were tested. To the results of these tests were added the results of tests done previously by the authors on 582 young adults.

The instruction sheet to the physical-education teachers included the following directions:

Test I: Reach finger tips toward toes, sitting with knees *straight*, feet at right angles, toes relaxed (Charts 1-A and 1-B).

If the individual is unable to touch toes, measure the distance from middle finger to toes. Measurement should be made of held position, without any forcing or jerking forward.

Test II: Bend forehead toward knees, sitting with knees *straight* and arms folded on chest (Charts 2-A and 2-B).

Place a thin ruler (or cardboard) flat on knees; then with a second ruler, measure distance from forehead (nearest point) of subject to knees. For those children who are able to touch forehead to knees, please check as to any special activities, such as acrobatics or

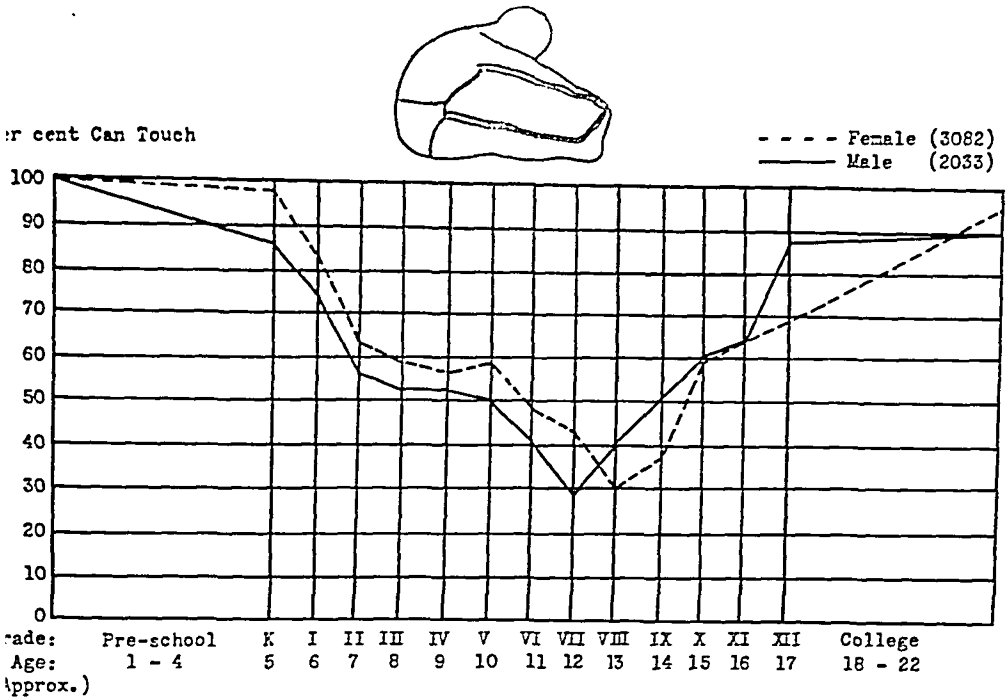

CHART 1-A

MALE					FEMALE			
Range of Limitation	Mean	% Can Touch	Total Ex'd.	Grade Age	Total Ex'd.	% Can Touch	Mean	Range of Limitation
½" - 9"	2¾"	86%	102	K 5	102	98%	3¾"	3½" - 4"
1" - 10"	4"	74%	125	I 6	108	83%	3"	½" - 4"
½" - 10½"	3"	56%	147	II 7	152	63%	3½"	½" - 10½"
½" - 9½"	3½"	52%	150	III 8	192	59%	4"	1" - 8½"
½" - 10½"	4½"	52%	150	IV 9	158	57%	4½"	1" - 13½"
1" - 10"	4½"	50%	158	V 10	174	59%	4"	½" - 8"
1" - 11½"	4¼"	41%	140	VI 11	156	49%	4½"	½" - 10"
½" - 9½"	4"	28%	100	VII 12	100	43%	6"	½" - 11½"
1½" - 13"	4½"	40%	151	VIII 13	115	30%	5"	½" - 10"
½" - 10"	4½"	50%	222	IX 14	108	37%	5½"	.2" - 13"
½" - 12½"	3½"	60%	100	X 15	498	59%	5"	½" - 12"
½" - 12½"	5"	64%	100	XI 16	507	64%	5"	1" - 12"
1" - 12"	3"	87%	113	XII 17	405	69%	5"	1" - 14"
1" - 11"	4"	90%	275	18-22	307	95%	3"	1" - 6½"
Total number tested: 2033					3082 :Total number tested			

CHART 1-B

Test I—Touching finger tips to toes. Measurements of 5,115 individuals.

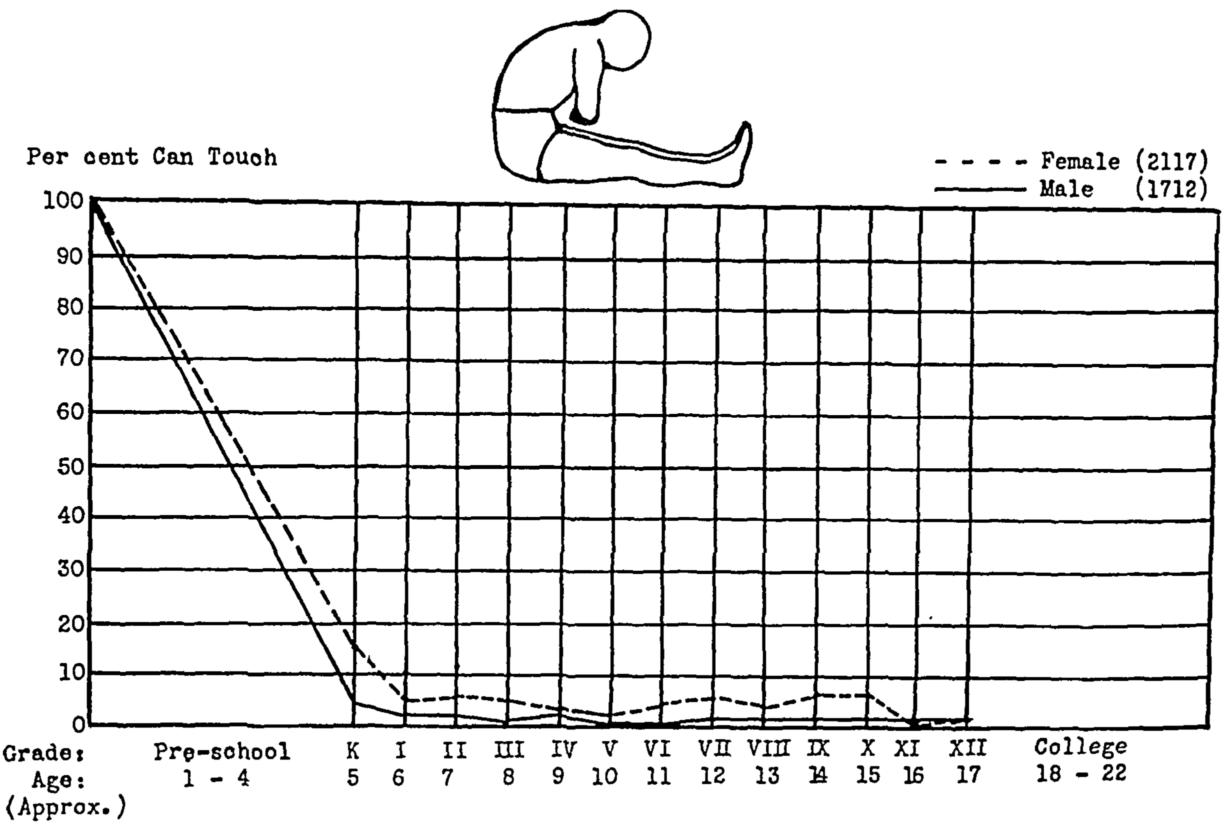

CHART 2-A

MALE					FEMALE			
Range of Limitation	Mean	% Can touch	Total Ex'd.	Grade Age	Total Ex'd.	% Can touch	Mean	Range of Limitation
½" - 10"	5"	5%	102	K 5	102	16%	4"	½" - 7½"
2" - 11½"	7"	2%	125	I 6	108	5%	6"	½" - 10½"
3" - 13"	7½"	2%	147	II 7	152	6%	7"	1" - 13½"
½" - 11"	6½"	1%	150	III 8	192	5%	6"	1" - 11½"
4" - 14"	9"	2%	150	IV 9	158	3%	7½"	1" - 12½"
1" - 12½"	7"	0	158	V 10	174	2%	6"	1" - 10½"
1½" - 15"	7½"	0	140	VI 11	156	4%	6¾"	2" - 11½"
3½" - 13½"	9"	1%	100	VII 12	100	5%	6"	½" - 11½"
1" - 18"	8"	1%	112	VIII 13	115	4%	7"	1½" - 20"
2" - 19"	10"	1%	215	IX 14	129	6%	7"	½" - 12"
1½" - 19"	9"	1%	100	X 15	173	6%	8"	1" - 18½"
2½" - 23½"	11"	1%	100	XI 16	277	0	8"	1" - 18½"
½" - 18"	8"	1%	113	XII 17	281	1%	8"	1½" - 20"
Total number tested: 1712					2117 :Total number tested			

CHART 2-B

Test II—Bending forehead toward the knees. Measurements of 3,829 individuals.

dancing, that might account for their ability to perform this movement. Make a special sheet for this group of children, giving any pertinent information.

RESULTS

Explanation of Chart 1-A

No infants or pre-school children were examined, but accomplishment of this test movement is considered normal for an infant. At the age of five, 98 per cent. of the girls and 86 per cent. of the boys can touch finger tips to toes with knees straight. A sharp decline follows, so that only about 30 per cent. of the boys and girls at the ages of twelve and thirteen, respectively, can perform the movement. This low point is followed by a marked rise, for five years or more, in the percentage of persons able to complete this test movement.

The test results on young adults were not classified on the basis of age; hence they are grouped in the graph. The males in this adult series were students at a military academy, and may represent above-normal degrees of flexibility. However, tests done by the authors on other adults, not included in this series, substantiate these findings. The females in this series were student nurses at the Johns Hopkins Hospital, examined at the time of admission to nurses' training.

Explanation of Chart 1-B

Reading from the center outward, the columns represent the following:

1. Total number of each age-group examined, both males and females.
2. Percentage of individuals in each age-group who can touch finger tips to toes (as plotted in Chart 1-A).
3. The *mean* distance of finger tips to toes, computed on the basis of those who are unable to touch.
4. The range of limitation among those unable to touch finger tips to toes.

There has been no attempt to give percentages on the basis of the total number examined, because age-level differences are far more important than over-all averages in this particular test.

It was considered of interest to determine whether any muscle restriction was associated with the lack of flexibility. An angle of approximately 85 degrees in the single straight-leg-raising test for hamstring tightness was used as normal. The contour of the back was carefully observed in forward bending, to determine the presence of back tightness.

In a series of fifty-three boys in Grade 7, the restriction was found to be as follows: Thirty-one had hamstring tightness (twelve slight, sixteen moderate, and three marked); one had back tightness; two had both back and hamstring tightness; and nineteen could not be classified as having any muscle restriction, but as showing a mechanical inability to touch the toes because of the length of the lower extremities. These nineteen individuals appeared to exhibit a stage of growth in which the lower extremities were abnormally long in relation to the trunk.

Thirty girls of the same grade, who showed limitation, were checked, with these findings: Nineteen showed hamstring tightness (eleven slight, six moderate, and two marked); six showed back tightness; three had both back and hamstring-muscle tightness; and two had no muscle tightness.

The range of limitation in forward bending varied from one-half inch to fourteen inches, with the *mean* approximately four and one-half inches for females and four inches for males.

Explanation of Chart 2-A

The ability to touch forehead to knees, when sitting with knees straight, may be considered normal for an infant. By the age of five, only 16 per cent. of the girls and 5 per

cent. of the boys could touch forehead to knees in this position. The number drops, so that between the ages of six and eighteen the average is approximately 1 per cent. for the boys and 4 per cent. for the girls. Of forty-four girls reported as being able to touch forehead to knees, twenty-three had had acrobatic or ballet dancing for varying periods of time, which suggests that approximately half of the girls had an acquired rather than an innate ability.

Test results are incomplete for young adults, and have been omitted on the graph.

The position of the arms (folded on the chest) has been questioned because of the possibility that such a position might limit flexibility. Testing the same individual with arms down and with arms folded on chest shows that the head is approximately one-half inch closer to the knees when the arms are down. However, in testing a large number of persons, the folded position of the arms has been found to ensure against assistance by the arms in a pulling or pushing movement, and makes test results more accurate.

Explanation of Chart 2-B (to be read according to the explanation for Chart 1-B)

The test results shown in this survey are similar to those reported by Gurewitsch and O'Neill. These authors reported test results on five separate test movements, one of which appears to be essentially the same as Test II in this paper. Another is essentially the same as Test I in this paper, except that Gurewitsch and O'Neill's test was done with the subject in the standing position, whereas that reported here was done with the subject in the sitting position.

The authors consider it advisable to do the flexibility test (Test I) with the subject in the sitting position. It has been observed that forward bending in the standing position may be limited by a unilateral pelvic tilt, or by clockwise or counter-clockwise rotation of the pelvis in relation to the thorax. The lateral tilt or rotation tends to disappear with the subject in the sitting position, with the result that frequently individuals who cannot touch the floor when standing can touch the toes when sitting. Such findings are more common among adults than among children, but should be considered in testing a large series of all age groups.

As pointed out by Gurewitsch and O'Neill, many factors influence test results. Children should not be given advance notice of the tests, nor should they be permitted to practise the test movements. In the series reported in this paper, school differences appeared which necessitated a sampling from various schools in several grades. Such differences were probably due to the influence of physical-education procedures, which vary to some extent with schools.

The average distance from head to knees in Test II was 6.9 inches for those unable to touch in the Gurewitsch and O'Neill series, which compares closely with the *mean* of six and one-half inches for females and eight inches for males in this series. The range of limitation in this series varied from one-half inch to twenty-three and one-half inches.

Both studies showed that girls are more flexible than boys; and, in both, the age of twelve represented the period when the smallest number of children could touch finger tips to toes with the knees straight.

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AN EVALUATION OF CERTAIN NON-OPERATIVE METHODS USED IN THE TREATMENT OF CEREBRAL PALSY

BY HERBERT E. HIPPS, M.D., WACO, TEXAS

Several years of experience in the conservative treatment of cerebral palsy have caused the author to doubt the value of some of the commonly used therapeutic procedures. A review of the current literature did not clarify the subject. Hence it was decided to test the more common therapeutic agents by using only one at a time, for a specific period, on a group of patients, and to attempt to measure the beneficial results of each.

PROCEDURE

Thirty-five patients with cerebral palsy were selected for this study: eighteen were predominantly of the spastic type, twelve were largely of the athetoid type, and five were of the ataxic group. Their ages ranged from six to seventeen years. All patients were considered to be of average intelligence. None had had convulsions since the first year of life. All those in the spastic and athetoid groups could balance themselves in a sitting position. Children were purposely selected who would be expected to show a fairly rapid response to treatment, in order to lessen as much as possible the over-all time necessary for this study.

The evaluation of each of these measures was based on a few relatively accurate tests and measurements, supplemented by the opinions of the doctor in charge of the case, the physiotherapist who gave the treatments, the nurse or nurses who took care of the child on the ward, and the child's mother.

On the second or third day after admission, each child was examined and given tests applicable to his type of involvement. Then, for not less than one month and not more than four months, he was treated each day by only one of the methods under consideration. At the end of the trial period he was given another test, and the results were recorded. Either immediately after this trial period or during another period in the hospital, another method of treatment was started and carried on for the necessary period of time; after this the patient was again tested. The different types of treatment were never used concurrently during these tests.

If, after four weeks, it became evident that a child was not making progress under one of these treatment procedures, the test period was continued no longer; or if, in this same period of time, he showed a distinct measurable improvement, the trial period was terminated.

Since most patients of average intelligence improve slowly with the passage of time, regardless of treatment, a maximum time limit of four months was set for the completion of each test. A measurable improvement, occurring within that relatively short period of time, may justifiably be attributed to the form of therapy used rather than to a natural degree of recovery.

TESTS AND MEASUREMENTS

Measurements of the degree of voluntary motion the child could carry out in a certain joint, against contracted muscles, were possible in the spastic group of patients, and they were fairly accurate.

Measurements of muscle coordination were obtained by having the child color a circle of a certain size with a red pencil. The number of times the pencil mark went over the circle line at each test, plus the general appearance of the coloring pattern and the time consumed in coloring, gave a fairly accurate picture of the behavior of the muscles.

Since the ataxic patients could not balance themselves in a sitting position unless they

had a back rest, the ability to sit alone was used as a mark of their progress. The duration of each successful balancing effort was timed and recorded for each successive measurement.

The ability to relax was measured by timing the interval between the request to relax and the patient's accomplishment of that state.

A simple wooden peg board, with the holes arranged in the form of a star, was used as an additional coordination test. The time necessary for the child to pull out and replace all the pegs served as a measurable criterion.

These tests and measurements were always made at the same time of day, in the same room, by the same person, under as nearly identical conditions as possible.

The opinions of the physiotherapist and of the doctor were recorded separately; and in each instance this was done before the final test was given to the patient. The ward nurse's opinion of the child's progress was usually based on the practical aspects of his ability to dress himself, comb his hair, wash his teeth, and take care of himself in general.

The recorded opinions as to the patient's progress were based largely upon the degree of his ability to execute a voluntary movement on command, and not upon his ability to relax. Although relaxation is an important step in training, the ability to relax alone is of little practical value to a child. Too often have we seen children who, after long periods of training, had been taught to relax, and who could do so completely; yet these children, on attempting to carry out some requested movement, immediately lost all their relaxation and returned to their previous spastic or athetoid state, still unable to execute successfully a practical, worth-while, volitional effort.

Explanation of Treatment Used

Muscle Stretching: The effort to correct spastic contractures and deformities was encouraged by manually stretching contracted muscles. For example, a scissor deformity of the lower extremities was treated by stretching the tight adductors. A flexed elbow was repeatedly stretched into a position of extension.

Prolonged Immobilization: This was usually accomplished with casts. The legs in a scissor deformity were held in an abducted position by two long casts with a stick between them.

Guided Rhythmical Passive Motion: If a knee would not straighten, it was gently flexed and extended in short, easy rhythmical movements, and the degree of extension was gradually increased as additional muscle relaxation was obtained.

Light Massage: This consisted in soft, soothing, slow stroking of tense, unruly muscles.

Heat: The affected extremities or parts were baked with an infra-red lamp.

Bracing: Usually thigh-length, pelvic-band braces were applied to the lower extremities of a spastic or athetoid child who could not walk, and he was placed between parallel walking bars and taught to walk. Later he used crutches and these braces; and, as he made progress, the braces were shortened.

Pool: Patients with cerebral palsy did not go into the pool with other patients. Their exercises in the pool were carefully guided, and were carried out in such a way as to take advantage of the buoyancy and warmth of the water.

Coordination Exercises: These exercises were carried out by the use of special toys, which necessitated a certain degree of coordination and dexterity in the affected extremity. Some of them required the use of only one extremity; others required the use of both hands; and still others needed the coordinated use of all four extremities. During his daily exercise periods, the patient played with these toys and was instructed in the proper use of them. Some of the toys and exercises included building blocks, hammer, wagon, and drum, for only one extremity; modeling clay, accordion, popgun, winding musical tops, cutting paper dolls, and looking at a comic book suspended by a string, for both extremities. For coordination of four extremities, we used the ladder bars, a scooter or a tricycle elevated on a stand so that it would not roll, and a jungle gym (pipe maze).

TABLE I

ANALYSIS OF IMPROVEMENT AFTER VARIOUS TYPES OF TREATMENT IN SPASTIC GROUP

Type of Treatment	Joint Measurement		Peg Board		Opinion of Mother		Opinion of Nurse		Opinion of Physiotherapist		Opinion of Doctor		Ability to Relax		Circle Test	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Muscle-stretching exercises	0	18	0	18	3	15	0	18	0	18	0	18	0	18	0	18
Prolonged immobilization	4	14	0	18	12	6	0	18	4	14	4	14	0	18	0	18
Guided rhythmical passive motion	10	8	6	12	18	0	5	13	14	4	12	6	9	9	9	9
Light massage	7	11	2	16	16	2	4	14	5	13	6	12	4	14	1	17
Heat	0	18	0	18	1	17	0	18	0	18	0	18	2	16	2	16
Bracing (walking)					18	0			18	0	16	2	0	18		
Pool	7	11	4	14	18	0	9	9	16	2	13	5	15	3	2	16
Coordination exercises	18	0	16	2	18	0	17	1	18	0	18	0	6	12	18	0
Diversion exercises	18	0	12	6	18	0	18	0	18	0	18	0	10	8	17	1
Repetitious individual efforts	16	2	17	1	18	0	18	0	18	0	18	0	17	1	18	0

Yes = Improvement.
No = No improvement.

Diversion Exercises: This is a method of getting the child to exercise the extremity in the required way, while his attention is diverted to something else. We had often noticed that a child could perform a certain movement, such as opening his hand, when no one was near him, but that when he was asked to do it, intense spasm and incoordination occurred and the fingers flexed tighter than ever. The diversion was usually soft, rhythmical, waltz-time music. For example, the child lay on his back on a mat, and was taught to raise the arm and drop it in time to the music. This exercise was applicable to all four extremities. Marking on a blackboard, hammering, or other similar activities were also done in time to music.

TABLE II

ANALYSIS OF IMPROVEMENT AFTER VARIOUS TYPES OF TREATMENT IN ATHETOID GROUP

Type of Treatment	Circle Test		Opinion of Mother		Opinion of Nurse		Opinion of Physiotherapist		Opinion of Doctor		Peg Board		Ability to Relax	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Prolonged immobilization	0	12	0	12	0	12	0	12	0	12	0	12	0	12
Light massage	2	10	12	0	0	12	0	12	0	12	1	11	4	8
Heat	0	12	6	6	0	12	0	12	0	12	0	12	0	12
Pool	5	7	12	0	3	9	6	6	4	8	2	10	2	10
Coordination exercises	6	6	12	0	10	2	12	0	12	0	8	4	6	6
Diversion exercises	8	4	12	0	12	0	12	0	12	0	8	4	7	5
Bracing for walking			12	0			6	6	6	6				
Repetitious individual efforts	12	0	12	0	12	0	12	0	12	0	12	0	11	1

Yes = Improvement.
No = No improvement.

TABLE III

ANALYSIS OF IMPROVEMENT AFTER VARIOUS TYPES OF TREATMENT IN ATAXIC GROUP

Type of Treatment	Balancing-Interval Time			
	Sitting Still Only		Sitting Still plus Arm Movements	
	Improvement	No Improvement	Improvement	No Improvement
Pool	5	0	3	2
Bracing (special chair)	5	0	5	0
Light massage	1	4	0	5
Repetitious unaided balancing efforts ..	3	2	2	3

Repetitious Individual Efforts: The child was given a job to do, an exercise to perform or an objective to accomplish, and was urged constantly to do it by himself. He tried and tried, again and again. He may have been commended, praised, cajoled, or even remonstrated with, but never was he helped manually or with apparatus in the performance of that one thing. When he became tired or nervous, he rested; but, when rested, he tried and tried again for long periods of time to master that one requirement.

DISCUSSION OF RESULTS

This study was conducted primarily to determine which treatment procedure was of value, and which was not of value. It was not intended to be a quantitative analysis of the respective merits of each procedure, and could not accurately be so, chiefly because of the variable time factor in the trial period of each test. Nevertheless, it was fairly obvious that some procedures were distinctly of more value than others.

An analysis of the statistical details (Tables I, II, and III) indicates that the following individual therapeutic measures, as defined, are of no value in the treatment of spastic and athetoid patients: muscle-stretching exercises; prolonged immobilization; heat, in the form of baking; and light massage.

The following procedures are of limited value: guided rhythmical passive exercises and pool therapy.

The most valuable procedures are: bracing (for walking), coordination exercises, diversion exercises, and repetitious unaided individual efforts.

No conclusions were formed in the ataxic group, as the number of patients was too small.

The repetition of individual unaided efforts apparently ranked high in efficiency among the treatment measures studied. However, this is really not a special treatment procedure, because no special techniques of training were used. The child learned by constantly trying. He learned in his own way. He learned as any other child learns to do things, by trying to do them. It is obvious, therefore, that improvement came about because of his constant prolonged efforts to do the one thing required of him. This should emphasize the importance of continuing our training efforts all day long, at every available opportunity, and not for an hour or a two-hour period each day.

From this work, we cannot be certain just what combinations of these measures would be of most value. However, if we combine those that individually are of proved value, and eliminate those that are of no value, our treatment of patients with cerebral palsy should be improved, particularly if we carry on with them for long periods of time each day.

It is of interest to note how often the mother could see improvement that was not discernible to others, and which did not manifest itself in the tests.

FRACTURE-DISLOCATION OF THE HIP JOINT

The Nature of the Traumatic Lesion, Treatment, Late Complications, and End Results

BY MARSHALL R. URIST, M.D.*, CHICAGO, ILLINOIS

Jeep accidents in the European Theater of Operations produced a large number of uncommon injuries of the hip joint. This paper presents twenty-seven cases of dislocation of the hip, associated with major fractures of the acetabulum or head of the femur, incurred under both combat and non-combat circumstances. The experience gained in the management of these cases provided an opportunity to determine the indications and the best techniques for primary surgical treatment. Review of the case records, operative notes, serial roentgenograms, and follow-up examinations, two years after the injuries, disclosed new information about the pathogenesis of avascular necrosis of the head of the femur.

The cases are classified according to the standard textbook classification of these injuries. The twenty-seven included fifteen cases of posterior dislocation with fracture of the posterior rim of the acetabulum (Table I); eight cases of fracture-dislocation, irreducible by closed manipulation (Table II); and four cases of posterior dislocation, associated with fracture of the head of the femur (Table III). Some cases of each group were treated conservatively and some by open operation, the decision depending upon (1) the author's clinical judgment in individual cases, (2) the physical and tactical circumstances in which treatment had to be administered, and (3) the results obtained from conservative treatment, which was attempted first in almost every case.

This report is the last of a series of three papers. A group of simple dislocations, reported in the first paper, were treated and followed at the same time as the cases reported in the present communication, and will serve as a control for evaluating the part of the injury concerning the joint capsule [4]. Fractures of the acetabulum, similar to those occurring in the cases presented here but without dislocation, were also treated concurrently and are being reported elsewhere in detail; these will serve as a control group for evaluation of the part of the injury affecting the bony structures [5]. The more difficult problem of the fracture-dislocation—the complex injury in which both the capsule and bony structure of the hip are involved—will be clearly outlined by a comparative analysis of the three groups of cases. This analysis is also useful in evaluating methods of treatment and the causes of late complications.

TRAUMATIC LESIONS

The nature of the injury to the joint was surveyed in fifteen cases of all types of fracture-dislocations, treated by open operation. The major damage was sustained by the following structures: acetabulum, periarticular ligaments, tendons, and muscles, the ligamentum teres, and the retinacula of the joint. Injury to the rim of the acetabulum, inflicted by a sudden impact of the dashboard of the automobile against the flexed knee, constitutes the first stage of a fracture-dislocation. The second stage is the excursion of the head of the femur, which tears the soft parts of the joint and lacerates the periarticular structures.

Acetabulum

The damage to the posterior rim varied in magnitude, and included insignificant

* Formerly Major in the Medical Corps, Army of the United States. Now at University of Chicago, School of Medicine.

TABLE I

FRACTURES OF THE POSTERIOR RIM OF THE ACETABULUM WITH REDUCIBLE POSTERIOR DISLOCATIONS OF THE HIP (MILITARY PERSONNEL)

Case No.	Age	Other Injuries of Ipsilateral Extremity	Treatment after Closed Manipulation	Operative Findings and Additional Procedures	Interval before Weight-Bearing Was Resumed (*Months*)	Condition at Follow-up (After Two Years)
1	28	Fracture of upper third of tibia and fibula	Open reduction, internal fixation	Three small bone chips removed	9	Excellent. Occasional minor pains
2	26		Open reduction, internal fixation	Extensive comminuted fracture of acetabulum. Large fragments replaced. Small chips removed	9	Good. Occasional minor pains
3	25		Open reduction, internal fixation	Large single fragment	9	Excellent
4	22	Contusion of knee	Open reduction, internal fixation	Large single fragment	4	Excellent
5	33	"Bumper fracture" of upper portions of tibia and fibula	Open reduction, internal fixation	Three large fragments, comprising entire superior and posterior portions of rim	6	Good. Occasional joint pain
6	25		Open reduction, internal fixation	Large fragment replaced. Three small fragments of inferior rim excised	Unknown	Unknown
7	25	Supracondylar fracture of femur	Open reduction, internal fixation	Large fragment replaced	Unknown	Unknown
8	24	Lacerated wound in prepatellar region	Traction for 8 weeks	X-ray showed imperfect reduction. No operation	12	Poor. Early degenerative arthritis
9	25	Compound dislocation of tarsometatarsal joints	Traction for 8 weeks	X-ray showed imperfect reduction. No operation	10	Poor. Early degenerative arthritis
10	25		Traction for 8 weeks	X-ray showed imperfect reduction. No operation	Unknown	Unknown
11	25		Traction for 8 weeks	X-ray showed imperfect reduction. No operation	Unknown	Unknown
12	29	Lacerated wounds of leg and knee	Traction for 8 weeks	X-ray showed imperfect reduction. No operation	Unknown	Unknown
13	25		Removal of comminuted fragments of posterior rim	One large fragment without soft-tissue attachments; corrugated articular cartilage; three small chips	9	Fairly good. Occasional joint pains. Early degenerative changes
14	22		Removal of comminuted fragments of posterior rim	Three small intra-articular fragments	5	Fairly good. Occasional joint pains
15	19	Lacerated wounds of knee	Removal of fragments of posterior rim	One large and three small chips detached from viable soft parts	6	Poor. Avascular necrosis of head of femur

TABLE II

COMMINUTED FRACTURES OF THE ACETABULUM WITH DISLOCATIONS OF THE HIP JOINT IRREDUCIBLE BY CLOSED MANIPULATION (MILITARY PERSONNEL)

Case No.	Age	Other Injuries of Ipsilateral Extremity	X-ray Findings	Definitive Treatment	Notable Operative Findings	Complications	Condition at Follow-up (After Two Years)
16 *	31	Lacerated wound of knee	Seven fragments of posterior rim	Arthrotomy by anterior iliofemoral approach. Fragments removed	Minor subchondral compression fractures of head of femur	Sciatic neuritis	Poor (painful hip)
17 **	29		Four fragments of posterior rim folded into joint	Arthrotomy by anterior iliofemoral approach. Fragments removed	Posterior soft parts macerated and torn	None	Fairly good
18 *	25	Severe contusion of knee	One large and three small fragments in and around joint	Arthrotomy by anterior iliofemoral approach. Fragments removed	Massive hemorrhage into reflected capsule of hip joint	Avascular necrosis with collapse of head of femur	Poor (arthrodesis)
19 **	25	Contusion and knee injury	Multiple fractures of acetabulum and pelvis	Vertical skeletal traction	No operation	Peroneal palsy. oedema of rectum	Poor (arthrodesis)
20 *	25	Fracture of patella	Multiple fractures of acetabulum and pelvis	None	Massive retroperitoneal and subdiaphragmatic hemorrhage	Peroneal palsy, oedema of rectum	Patient died of head injury
21 **	37	Severe contusions and hemarthrosis of both knees	Multiple fractures of acetabulum and pelvis; separation of symphysis pubis	Vertical skeletal traction	No operation	Peroneal palsy, oedema of rectum, hematuria. Traumatic stricture of posterior portion of urethra	Poor (arthrodesis)
22 **	29	Severe contusions and hemarthrosis of both knees	Multiple fractures of acetabulum and pelvis, separation of symphysis pubis	Vertical skeletal traction	Open reduction by anterior iliofemoral approach	Extensive ossification of all periarticular soft parts	Poor. Mold arthroplasty
23 *	25	Avulsion and ischaemic sloughing of skin of dorsum of leg	Displacement of inferior and posterior portions of rim across acetabular fossa	Open reduction and internal fixation posterior approach	Inferior rim and superior ramus of ischium formed single large fragment, displaced toward and obliterating acetabulum	Peroneal palsy	Unknown

* Two unsuccessful closed manipulations

** Three unsuccessful closed manipulations.

bruises or chip fractures, small fragments of the edge of the cotyloid labrum, larger crescent-shaped segments of the articular cartilage, and great segments of the entire posterior and superior portions of the acetabulum. Less than half the head of the femur lies outside the bony acetabulum in the normal hip and, after many of the supporting structures in the capsule had been ruptured, the integrity of the posterior and superior portions of the rim appeared to be of increased importance to the stability of the hip.

Soft-part attachments and the size of the bone fragments of the posterior rim determined the healing and the practicability of surgical repair to the joint. Small fragments of the edge of the rim showed little or no articular cartilage, were coated with cotyloid ligament on two sides, and frequently lay free in the hematoma in and around the joint. Only large fragments, four to seven centimeters in length, had broad attachment to the capsule, bled when curetted, and were assumed to have a sufficient blood supply to survive when replaced. The fracture was usually oblique and the articular side of the rim fragment was, fortunately, less than half as wide as the outer side (Fig. 6-C). The larger the fragment appeared in the roentgenogram, however, the more articular cartilage one could expect to find upon it at operation.

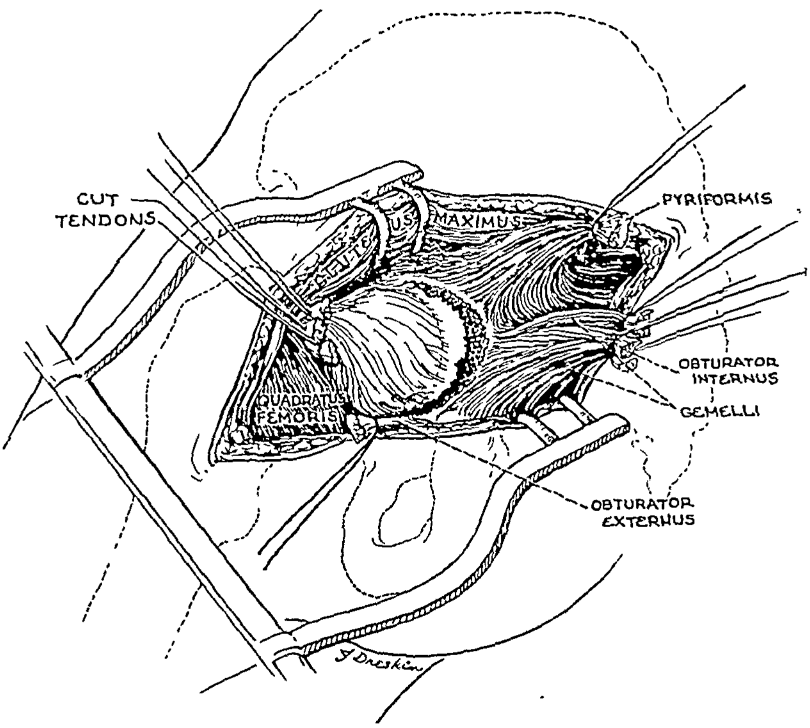

FIG. 1-A

Sketch shows fracture of posterior rim of left acetabulum, the posterior joint capsule, and the limits of the exposure in the posterior approach.

Periarticular Structures

The major damage to the soft parts of the joint was usually sustained by the parietal or external portion of the capsule, rather than the visceral or reflected part, which carries the major portion of the blood supply to the head of the femur. When a large segment of bone was detached from the rim, the capsule was essentially intact, except for a single tear in the posterior portion; and the head was dislocated into the fracture site. The short external rotator muscles, however, sustained considerable damage. The belly and tendon of the piriformis were stretched over the head of the femur. The tendon of the obturator internus was stretched over the neck. The gemelli were torn and shredded. All of these structures were infiltrated with blood and matted together with fibrinous exudate and granulation tissue; and dissection was difficult if operation was done longer than two weeks after injury. Comminuted fractures of the rim, in addition to all these changes, were accompanied by extensive, contused, lacerated wounds of all the posterior soft parts.

Femur

The head of the femur could be examined thoroughly by rotating it through its range of motion in all directions at the fracture site. Almost every case showed some damage to the articular surface of the head, but these lesions were small and not visible roentgenographically. Even fractures of some magnitude could not be demonstrated in antero-

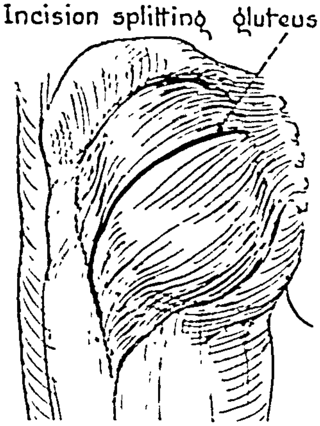

FIG. 1-B

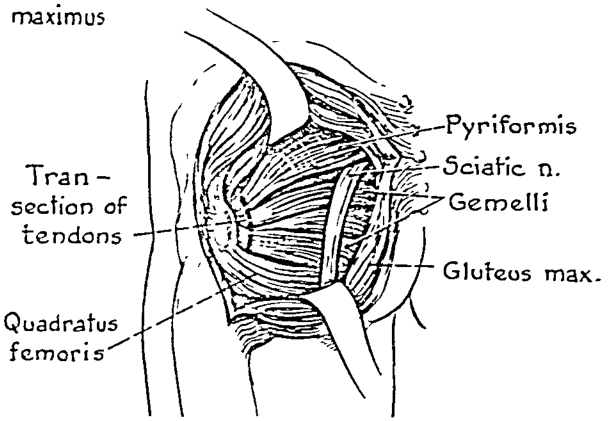

FIG. 1-C

Fig. 1-B: Sketch showing the superficial anatomical relationships on the posterior aspect of the hip joint. The reflection of a segment of the trochanteric insertion of the glutaeus maximus provides the relaxation necessary to develop a large window in the glutaeus maximus. (Redrawn from Fig. 117,*A* in Campbell's "Operative Orthopedics". Reproduced by permission of C. V. Mosby Company.)

Fig. 1-C: Sketch showing the small deep muscles and the relationships of the sciatic nerve. The piriformis, when reflected medially, envelops the sciatic nerve, and all further dissection is deep and lateral to the short external rotator muscles of the hip. (Redrawn and modified from Fig. 117,*B* in Campbell's "Operative Orthopedics". Reproduced by permission of C. V. Mosby Company.)

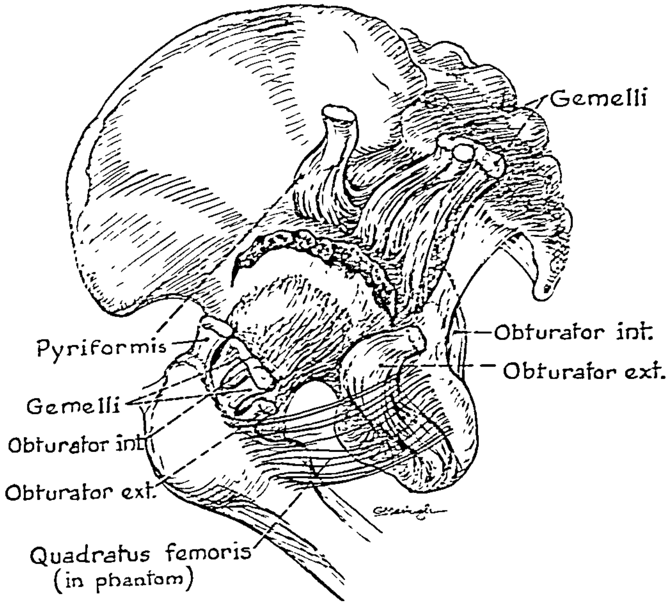

FIG. 1-D

Fig 1-D: Sketch showing the skeletal relationships, the fracture site, the short external rotator muscles reflected medially, and the rent which is frequently found in the inferoposterior portion of the joint capsule.

posterior views alone, or in films made by routine or imperfect techniques. In five cases with rim fractures, lunate-shaped indentations were seen in the anterior aspect of the head of the femur, representing sites which had been cleft by the edge of the rim. In one case a circular flat depression (subchondral compression fracture), two centimeters in diameter, was noted on the anterior aspect of the head, as if the head had been tapped with a mallet. The surface of the bruised cartilage was dotted with pinhead-sized spots uniformly distributed, which represented the tufts of granulation tissue which form early in the process of repair.

Ligamentum Teres

In three cases in which the posterior portion of the acetabulum had been removed, the ligamentum teres was partly exposed for inspection and was found to be stretched and frayed. Complete visualization was possible in only two cases in which the hip had been disarticulated, and in both instances the ligamentum teres had been severed before the

operation. It is possible, in one case, that it was stretched and not torn apart; and that, in many cases, the excursion of the head was not so great as appeared in the roentgenograms.

FIG. 2-A

Case 1. Roentgenogram of a fracture of the posterior rim, central portion, and the inner table of the acetabulum, with posterior dislocation of the hip joint.

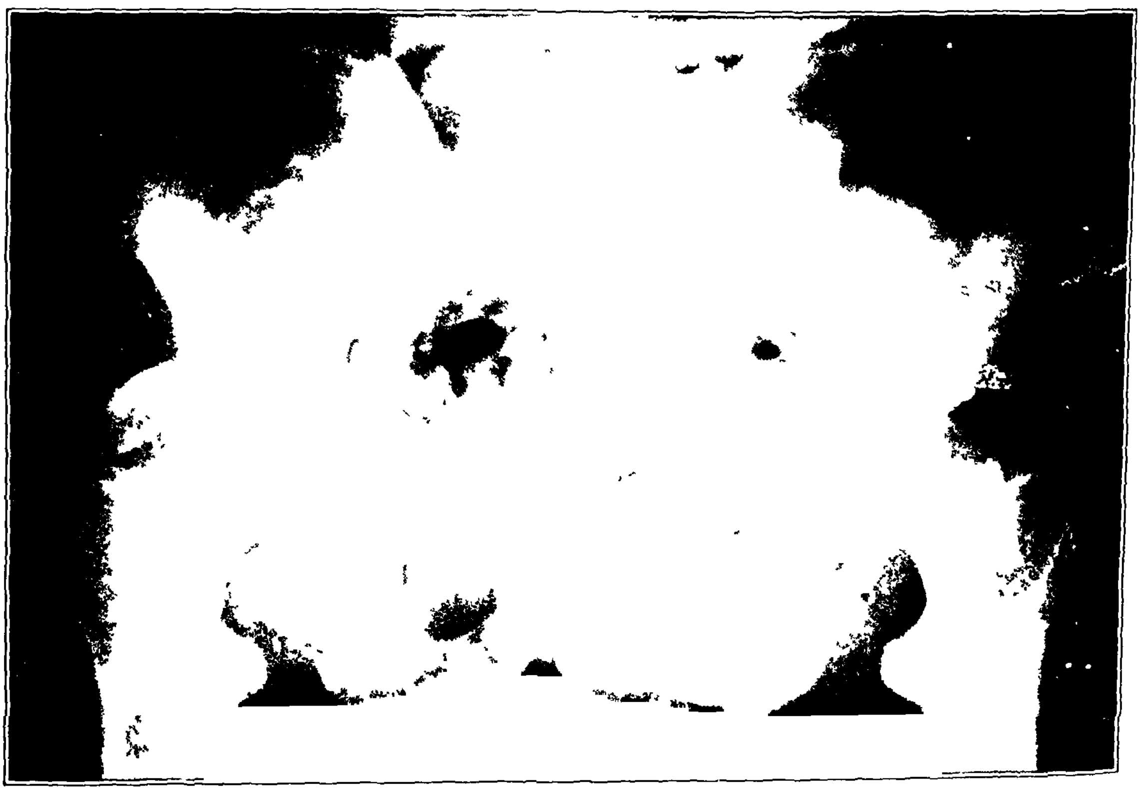

FIG. 2-B

After manipulation and reduction of the dislocation on the day of the injury. The posterior rim fragment remains widely displaced and unaltered by treatment in traction.

FIG 2-C

Postoperative roentgenogram, two weeks after the injury, showing reduction of the fracture of the posterosuperior rim of the acetabulum and internal fixation with a single screw.

Retinacula of the Hip Joint

Blood clot and organizing hemorrhage were seen in the retinacula in two cases. The significance of this observation was not realized at the time of the operation, and was surmised only one year later, when the records were reviewed for study and the roentgenograms of these patients showed avascular necrosis of the head of the femur. The importance of this finding and the relatively small amount of attention that retinacula have received in the clinical literature warrant a short description of the anatomy of these structures. They were first described by Josias Weitbrecht in 1742. The retinacula are three flattened bands of loose fibrous connective tissue, containing many blood vessels and covered with synovial membrane. They lie within and partly outside the reflected capsule on the inferior, postero-inferior, and posterosuperior aspects of the joint. They literally serve as aqueducts, carrying the blood supply to the head of the femur from numerous branches of the medial femoral circumflex vessels in the intertrochanteric region. The retinacula merge with the superior and inferior pads of fat at the margin of the articular cartilage, and there their blood vessels give off terminal arterial branches and receive the venous drainage of the capital epiphysis [6]. As will be shown further in a discussion of the late complications in this series of cases, the role of the retinacula in avascular necrosis demands further investigation in relation to both trauma and disease of the head of the femur.

FRACTURES OF THE POSTERIOR RIM OF THE ACETABULUM WITH DISLOCATION OF THE HIP

In the fifteen cases of fracture of the rim of the acetabulum with dislocation (Table I), the dislocation was reduced by closed manipulation just as readily and by the same methods as were the dislocations without fractures, reported in the first paper in this series. In about 25 per cent. of the cases, the diagnosis of fracture was not recorded: and in several other cases, extensive fractures were not appreciated by the surgeons who

administered emergency treatment and manipulated the dislocation. The oversight is easy to understand. Unless one knows intimately the roentgenographic appearance of the hip joint, the fracture may seem to be obscured by the head of the femur in films taken before reduction. In cases in which the fracture was finally noted in the postreduction films, a false idea of the apposition of the fracture lines was sometimes conveyed by examination of only the anteroposterior view of the hip. A true picture of the displacement of the rim fragments is best obtained in a postero-oblique view, with the injured side elevated 60 degrees, the patient lying supine on the cassette and thus placing the posterior portion of the acetabulum in profile.

FIG. 3

FIG. 4

Fig. 3: Case 2. Roentgenogram of a posterior dislocation of the hip joint with fractures of the rim and central portions of the acetabulum. The postero-oblique view demonstrates the displacement of the rim fragment better than other views.

Fig. 4: Case 6. Postero-oblique view of a fracture-dislocation, two weeks after closed reduction of the dislocation and three days after open reduction of the rim fracture, shows the accuracy of the repair. The articular cortex should be reconstructed as perfectly as possible, and the screw should penetrate both cortices to obtain good fixation and a good result.

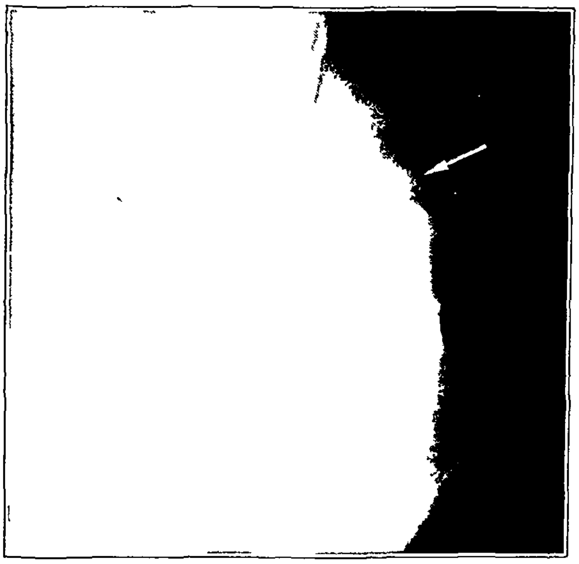

FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 3. A posterior dislocation of the hip with displacement of the fragments, shown in the postero-oblique view. A large rim fragment with its capsular attachment lies above the head of the femur.

Fig. 5-B: Two years after open reduction and internal fixation. Arrow indicates ossification of the attachments of small muscles and joint capsule.

Conservative Treatment

Conservative management by traction was applied in five of the fifteen cases. In three cases, this form of treatment was dictated by circumstances, the patients having head or abdominal injuries which took precedence over the hip injury. In the other two cases the rim fragments, although larger than chip fractures or avulsion fractures, yet were so small that any defect in the rim would not be large enough to affect the stability or range of motion of the joint.

Surgical Treatment

Ten patients with fracture of the posterior rim were treated, first by closed reduction of the dislocation, and then by arthrotomy. In seven cases the rim fragment was large, viable, and attached to the parietal portion of the capsule; and the fracture was reduced and immobilized by internal fixation with a screw (Figs. 1-A to 5-B, inclusive). In three cases (Cases 13, 14, and 15), either the lesions proved irreparable, the main fragments were detached from the blood supply, or the articular cartilage was so severely damaged that it was advisable to remove the posterior rim (Figs. 6-A through 6-G and 7-A through 7-E). The decision between replacement and fixation of the fracture or the removal of the fragments was naturally made at the time of the operation, and depended upon the presumed vitality of the bone fragments; but the operation itself was always indicated when there were loose fragments around the joint which might lead to migration of intra-articular bone, ossification of periarticular structures, irritation of the sciatic nerve, or the probability of a painful joint in later years.

Technique

The patient was placed in the prone position (with small pillows along the anterolateral aspect of the chest) on an operating table, equipped with a drop leaf under the hip, to permit the surgeon to make flexion manipulations. A posterior approach, similar to that described by von Langenbeck, Kocher, or Osborne, was used in all cases (Figs. 1-A to 1-D, inclusive). The incision was begun along a line drawn between the posterosuperior spine of the ilium and the inferior portion of the greater trochanter; at the latter point it was turned distally two inches (five centimeters) along the posterolateral aspect of the thigh. The whole length of the glutaeus maximus was split along its fibers, above the line of the neck of the femur. Through this opening the deep fascia, covering the short external rotator muscles of the hip, was widely exposed with the aid of the Balfour self-retaining retractor; thus a window, three inches square, was made in the glutaeus maximus. The exposure could be enlarged if a part of the insertion of the glutaeus was also transected. At this point the traumatic lesion in the short external rotator muscles, the capsule, and the joint was usually visible and found to be filled with blood clot, sometimes amounting to seventy-five cubic centimeters in volume. After the hematoma had been removed, the fracture line always came into view, and it was possible to see the glistening white head of the femur. Both sides of the fracture line were fully exposed by section of the tendinous insertions of the piriformis, obturator internus, gemellus superior, obturator externus, and gemellus inferior. Stubs of each tendinous insertion were left on the trochanter for later repair, and heavy black silk sutures were placed in each end of each transected tendon to facilitate retraction and reflection of the short external rotators. The sciatic nerve passed across the medial side of the operative field, in the plane between the piriformis and the gemelli. Reflection of the muscles medially, as shown in Figure 1-D, afforded protective covering for the nerve.

Further dissection was confined to the region anterior or deep to the external rotator muscles, and was done subperiosteally on the pelvic side of the fracture line. The periosteum or joint capsule was not lifted from the rim fragments, in order to avoid injury to the blood supply. After loose chips of bone and flakes of articular cartilage had been

removed, the main fragment could be fitted accurately into place by apposing the d-
edges as closely as possible. The position of adduction, 10 degrees of flexion, and

FIG. 6-A

Case 15. Roentgenogram of a posterior dislocation of the hip joint, with fracture of the rim of the acetabulum.

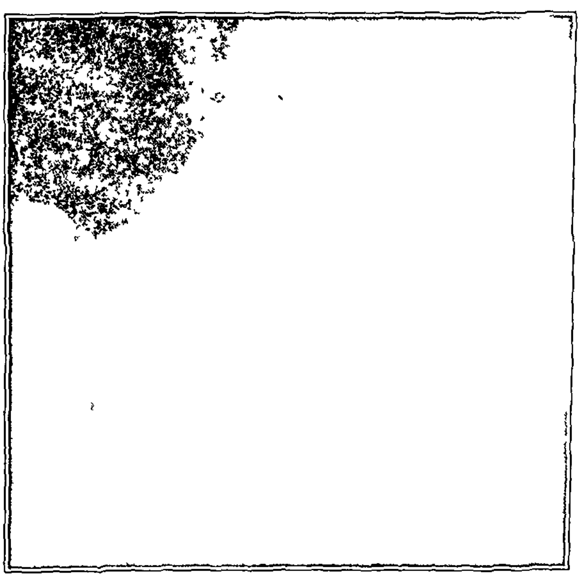

FIG. 6-B

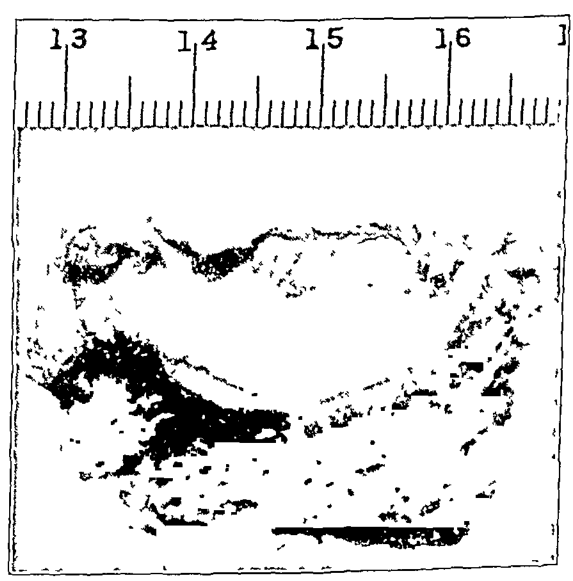

FIG. 6-C

Fig. 6-B: Following manipulation and reduction of the dislocation, the rim fragment remained displaced inferiorly. This position, rather than one superior and lateral to the head, which is the usual path of displacement of the posterior rim, indicates that the capsular attachments of the bone fragment have been lost or subjected to extensive injury.

Fig. 6-C: Specimen of the posterior rim of the acetabulum, removed at operation (measured in centimeters). The fragment was avascular, attached to a torn and twisted pedicle of joint capsule, and found to be completely devoid of blood supply. A segment which is nearly the complete width of the acetabular cartilage has been lost in this case. There was also a hemorrhagic lesion of the retinaculum, followed by the changes shown in Figs. 6-D to 6-G.

FIG. 6-D

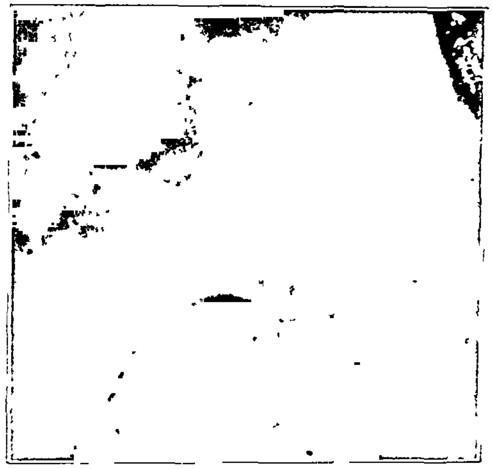

FIG. 6-E

Fig. 6-D: Anteroposterior view, two years after the original injury, showing necrosis of the superior segment of the head of the femur.

Fig. 6-E: Lateral roentgenogram, two years after the original injury. Note the cleavage line between the necrotic and the viable portions of the head. The dead bone is being separated and replaced by new bone.

FIG. 6-F

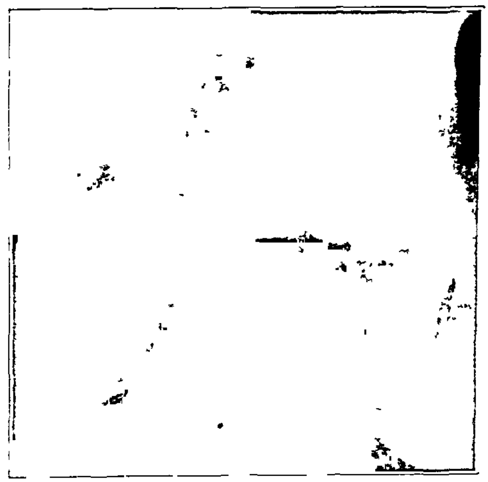

FIG. 6-G

Fig. 6-F: Anteroposterior roentgenogram, approximately two and one-half years after the injury, shows further absorption, separation, and replacement of the dead portion of the head.

Fig. 6-G: Lateral view, three years after the injury, showing sheering of the dead portion of the head away from the living bone posteriorly at the line of absorption and regeneration.

external rotation relaxed the posterior capsule and removed the pressure of the head of the femur, so that circumstances were favorable for holding a perfect reduction. The position of the screw was carefully estimated to prevent placing it too near the articular cartilage. It was placed nearly horizontal, at right angles to the plane of the fracture, and directed somewhat superiorly. A depth finder was used, to make certain that the screw had penetrated the cortex of the inner table of the pelvis. Bicortical fixation was necessary to withstand the test of cautious rotation and piston mobility, carried out at the conclusion of the repair. Reduction of the fragments simultaneously closed the defect in the posterior capsule. The operation was concluded by the excision of small amounts of shredded muscle tissue, repair of tendons of the small deep muscles, and closure of the wound in layers with black silk sutures.

Immediate postoperative care was instituted with the patient prone in bed and the

Fig. 7-A

Fig. 7-B

Fig. 7-A: Case 13. Postero-oblique view of dislocation of the head of the femur with fracture of the posterior rim of the acetabulum after the dislocation had been reduced by manipulation. The posterior rim remains displaced as usual, uninfluenced by conservative treatment in traction.

Fig. 7-B: Postoperative roentgenogram of both hips shows the amount of posterior rim which was absent in this case, due to irreparable damage and excision.

hip flexed 20 degrees over a pillow. Gluteal exercises were begun as soon as the sutures had been removed. At the end of five to ten days the patient was placed in the recumbent position, and the hip was suspended in ten pounds of skin traction in a Thomas splint with Pearson attachment.

Trends in Treatment

Although surgical treatment of fractures of the rim of the acetabulum began as soon as anaesthesia and roentgenography were developed, less than a hundred cases are reported in the literature. These operations were attempted at first on the so-called inveterate cases by means of posterior, anterior, straight lateral, or U-shaped incisions, and were intended mainly to reduce the displacement of the head of the femur. No attempt was made to replace the fragment of the rim of the acetabulum, and the fracture was not always correlated with the failure to reduce the dislocation by closed manipulations. There is disagreement in the modern textbooks and literature about the best approach for operations on old fracture-dislocations of the hip. This should not confuse the clearly defined problem of open reduction or removal of extra-articular bone

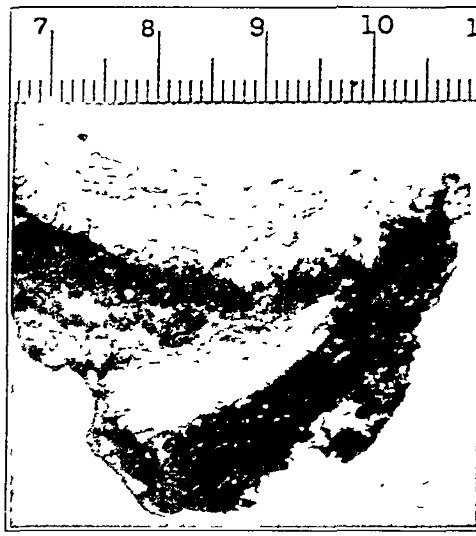

Fig. 7-C

Fig. 7-D

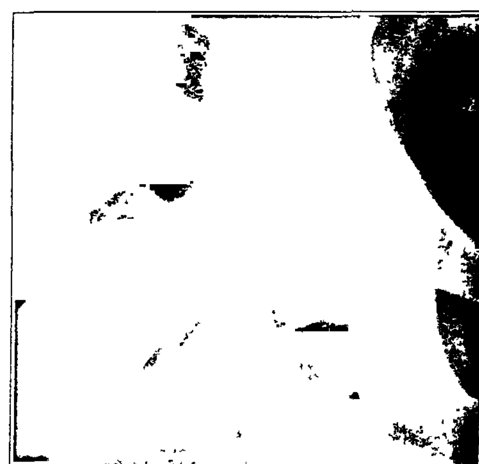

Fig. 7-E

Fig. 7-C: Specimen of the posterior rim of the acetabulum, removed at open operation. The extensive damage to the acetabular cartilage and the impacted fracture of the bone tissue contra-indicated replacement of this fragment. There were no retinacular hemorrhages in this case and avascular necrosis did not follow (see Figs. 7-D and 7-E).

Fig. 7-D: Roentgenogram of the hip joint, two years and ten months after excision of the posterior rim. In the anteroposterior view, the superior surface of the head shows irregularities and slight sclerosis, presumably due to irregular wear and tear on the articular surfaces.

Fig. 7-E: Lateral view of head of the femur. The area of degenerative changes in the head of the femur corresponds to the area of the fracture defect of the articular surface of the acetabulum. There is, as yet, very little, if any, narrowing of the joint space.

fragments, following a fresh fracture of the posterior rim of the acetabulum. A number of recent case reports testify that the posterior approach is particularly suited to posterior dislocations associated with fracture of the rim. The successful use of this method,

particularly the Osborne modification of the von Langenbeck and Kocher approaches, in eleven cases of both reducible and irreducible dislocations treated by the writer, may be added to the literature as further evidence of its value.

FRACTURES OF THE ACETABULUM WITH POSTERIOR DISLOCATIONS IRREDUCIBLE BY CLOSED MANIPULATION

The cause of failure to reduce posterior dislocation of the hip in eight cases in this series was the interference of displaced bone fragments of a fracture of the acetabulum. These cases will be considered in two groups: (1) comminuted fractures of the posterior and superior portions of the rim with intra-articular displacement of fragments (three cases); and (2) extensive fractures of the entire acetabulum with disorganization of the joint cavity (five cases).

FIG. 8-A

Case 18. Roentgenogram of a posterior dislocation with a comminuted fracture of the posterior rim of the acetabulum.

The patients (Table II) arrived in General Hospitals in the Communications Zone after at least two unsuccessful attempts at closed reduction had been made in each case in Field and Evacuation Hospitals. Improved roentgenograms, including stereoscopic examinations, revealed either that the head was obstructed by bone fragments of the rim, or that the joint cavity was so

FIG. 8-B

FIG. 8-C

Fig. 8-B: Roentgenogram after closed reduction of the dislocation, which was accomplished immediately after the injury. A fragment of bone was carried into the acetabular fossa during the manipulation. This antero-oblique view of the joint gave the best demonstration of the fragment and its relation to the head of the femur.

Fig. 8-C: Antero-oblique roentgenogram after removal of the bone fragment, three weeks after injury. The loss of articular surface appears to be small, but actually it is considerable, as shown in Fig. 8-D.

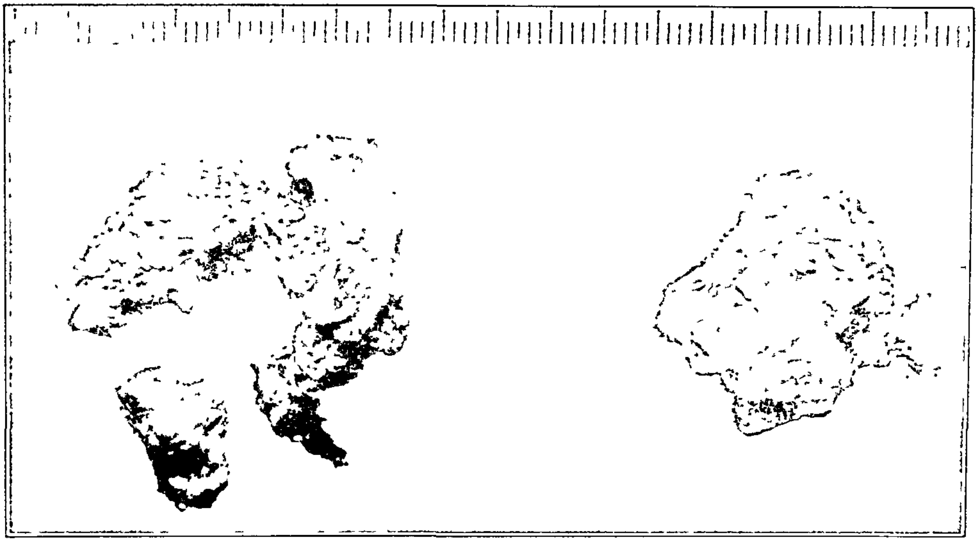

Fig. 8-D

Fig. 8-D: Photograph showing bone fragments removed from the joint by anterior iliofemoral arthrotomy, three weeks after injury. The large fragment on the right was removed from the acetabular fossa. The three smaller fragments on the left were imbedded in the posterior soft parts, poorly attached by shreds of capsule or cotyloid ligament.

Fig. 8-E: Roentgenogram, twenty months after arthrotomy, showing avascular necrosis of the head of the femur. The collapse of the bone structure was not prevented by having the patient use crutches for nearly two years.

Fig. 8-E

deformed and distorted that it could not receive the head of the femur. It was, therefore, anatomically impossible to effect reduction in any of these cases by closed manipulation. Conservative treatment in traction was of limited value in both groups of cases, but it was essential for the patient s comfort, and it was necessary temporarily to retain anatomical approximation of the head of the femur and the fractured pelvis.

Comminuted Fractures of the Posterior Rim of the Acetabulum

After the closed manipulations in three cases (Cases 16, 17, and 18), bone fragments lodged between the head of the femur and the joint cavity and obstructed the reduction. In one of these three patients (Case 18), an attempt was made to disengage these intra-articular rim fragments by pulling the head of the femur down over them and thrusting it inward with grinding and scooping movements, but these manoeuvres were futile and harmed the joint surfaces. Immediate open operation was required in each of the three cases.

Removal of Intra-Articular Bone Fragments

The anterior iliofemoral approach was considered advisable for arthrotomy and removal of intra-articular bone fragments in three cases. The anterior portion of the capsule

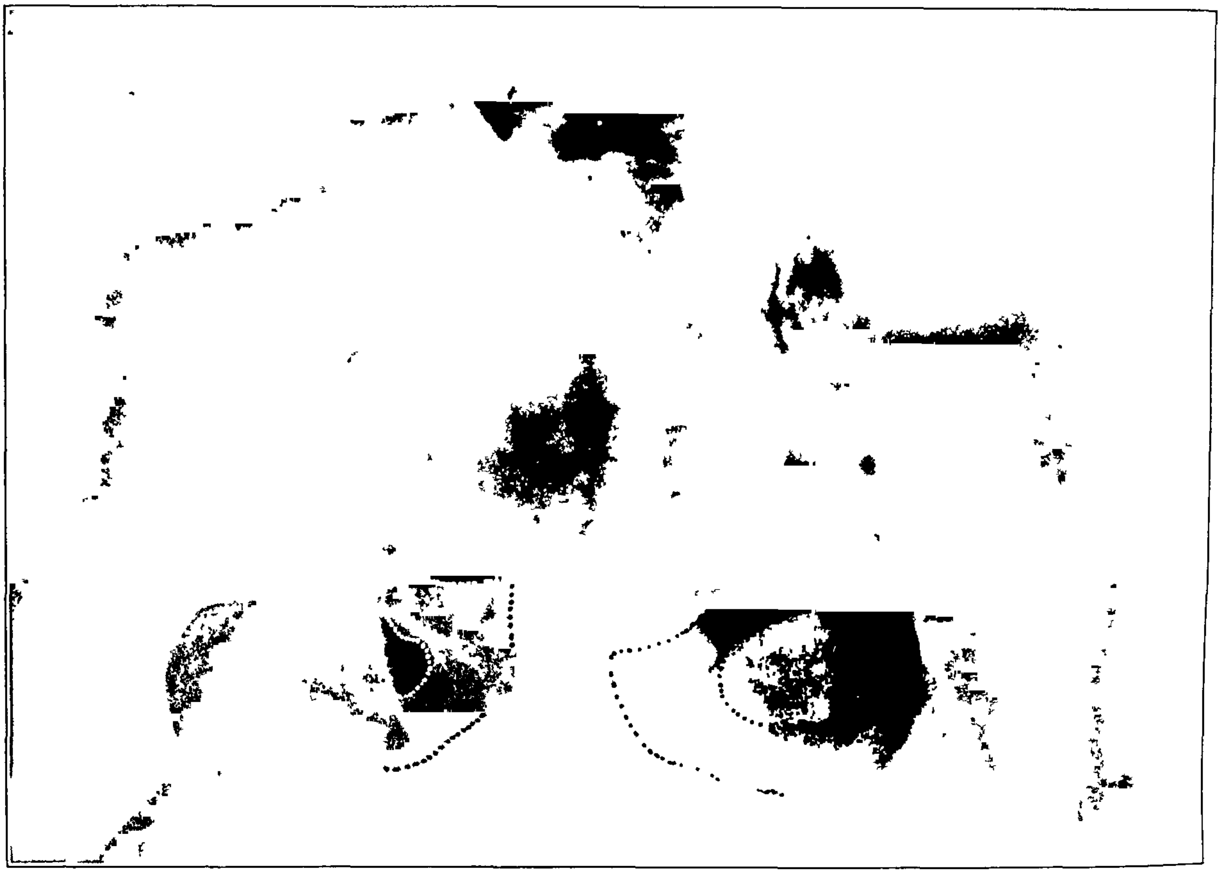

FIG. 9-A

Case 21. Roentgenogram (retouched) of an extensive fracture of the acetabulum, with dislocation and disorganization of the hip joint and separation of the symphysis pubis.

FIG. 9-B

Roentgenogram with patient in vertical skeletal traction after closed manipulation, showing reduction of the dislocations.

was found to be intact, but the superior and posterior portions were stretched, frayed, and torn. All of the bone fragments which were one square centimeter or larger in size were attached to pedicles of torn capsule or strips of the short external rotator muscles. In order to replace the head of the femur in the joint, it was necessary to apply traction and at the same time to pry loose the interposed capsule, muscle, and torn tendon with the aid of a smooth, flat instrument. In Case 18 the hip had to be disarticulated with the aid of an incision in the intact anterior portion of the capsule, in order to remove a large fragment of bone lodged in the acetabular fossa. In all of these cases, however, the obstruction to replacement of the head was the interposition of the soft-part attachments of the bone fragments, and not the pieces of bone themselves, as would appear from the roentgenograms alone (Figs. 8-A to 8-E, inclusive).

Disorganization of the Hip Joint and Sciatic-Nerve Palsy

In five cases (Cases 19, 20, 21, 22, and 23) extensive fractures of the entire acetabulum and surrounding pelvis had occurred, in addition to dislocation of the hip. Manipulations were undertaken to restore the length of the extremity and to place the head of the femur in a more suitable anatomical relationship to the pelvis. Because of the high risk of injury to the sciatic nerve, such manipulations were justified only if done very skillfully. They were nevertheless carried out in Cases 21 and 22, in which separations of the symphysis pubis and rupture of the sacro-iliac joint were associated with the hip lesion. In one of these cases (Figs. 9-A, 9-B, and 9-C), the separated symphysis pubis became reduced when the head of the femur was replaced in the joint. The popular method of placing the patient on his side was used first in both instances, and was found to be ineffective.

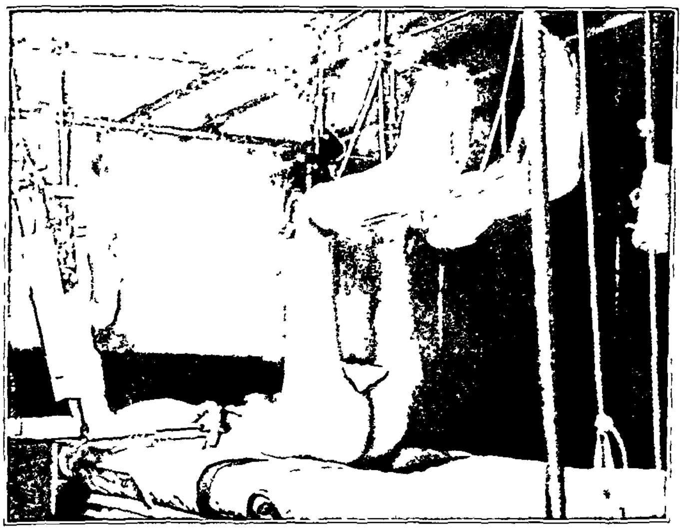

FIG. 9-C

Photograph of the patient, showing vertical skeletal traction. This was the only position which would prevent the head from redislocating and causing severe pain, radiating down the leg, from pressure on the sciatic nerve. The patient had several fractures in the arm and forearm, immobilized in skin traction, and an injury to the posterior portion of the urethra, which was treated. The virtue of this method of suspension was the comfort and facility with which the patient could receive the necessary nursing care. He could actively lift himself off the bed.

All except one of the five patients with disorganized hip joints were treated conservatively in traction and suspension for several weeks, until the patient's general condition would tolerate a major reconstructive procedure or transportation to a hospital for prolonged convalescent care. In the one exception (Case 23), peroneal palsy developed while the patient was under the author's observation, and exploration of the sciatic nerve and the displaced fragments of the acetabulum was indicated immediately. The operation proved to be worth while, and the case is described here (Figs. 10-A, 10-B, and 10-C).

Open Reduction and Exploration of the Sciatic Nerve

For this operation, the hip was exposed by the posterior approach already described. The sciatic nerve was discolored by ecchymosis for an area of about an inch; it was intact,

FIG. 10-A

Case 23. Roentgenogram shows an irreducible fracture-dislocation of the hip joint. The body of the ischium was impacted into the body of the ilium, and there was an associated fracture of the superior ramus of the ischium, all of which obliterated the joint cavity.

FIG. 10-B

FIG. 10-C

Fig. 10-B: Roentgenogram, three weeks after open reduction of the dislocation and fractures. One screw held the posterior portion of the acetabulum accurately in position.

Fig. 10-C: Lateral roentgenogram, demonstrating the repair.

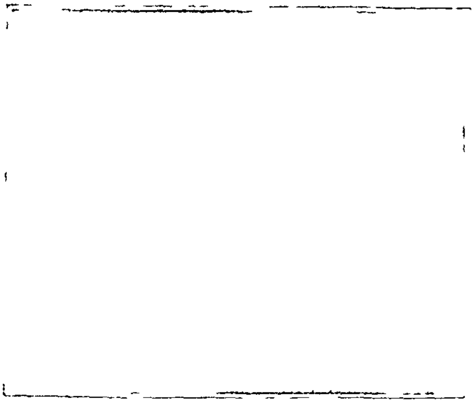

FIG. 11-A

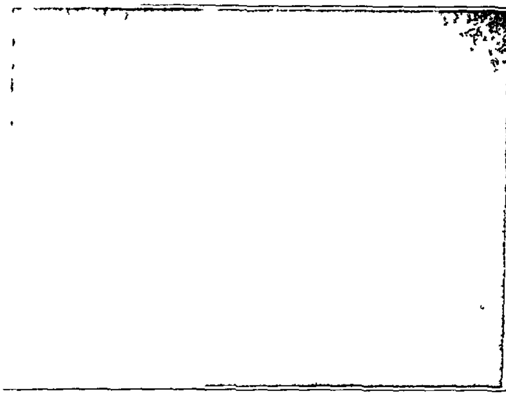

FIG. 11-B

Fig. 11-A: Case 24 Roentgenogram showing posterior dislocation of the hip with fracture of the head of the femur. The segment of the inferior portion of the head includes the fovea and remains in the acetabulum, attached to the ligamentum teres.

Fig. 11-B: Roentgenogram two and one-half years after the original injury The proximal fragment, which is demonstrable only with the head in extreme internal rotation, has reattached itself to the head and does not interfere with normal function of the joint

however, and was stretched over the large fragment of bone which represented the entire posterior portion of the acetabulum. Traction on the femur probably compressed the nerve in the soft parts between the head of the femur and the rim fragment, and apparently the peroneal palsy was produced in this way. In order to expose the joint cavity, the nerve was retracted medially; the head of the femur was adducted and internally rotated beyond the normal range; and the rim fragment was retracted laterally with a bone hook. The acetabulum was found to be obliterated by a displaced impacted fragment of

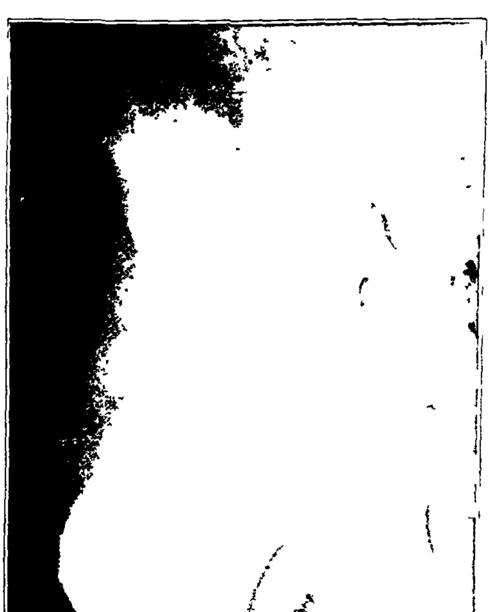

FIG. 12-A

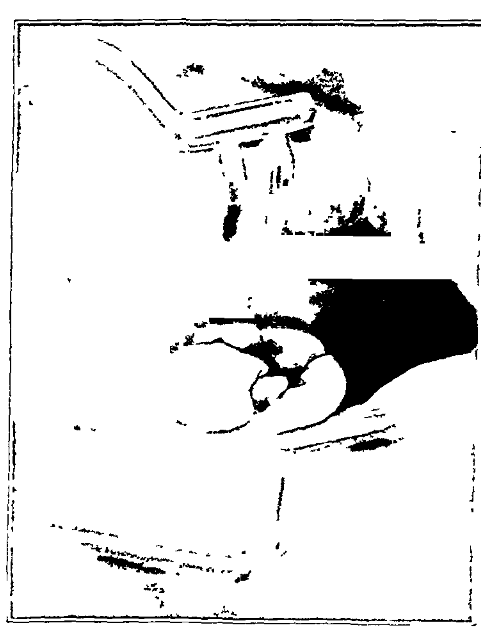

FIG. 12-B

Fig. 12-A: Case 26 Roentgenogram showing a fracture of the head of the femur with posterior dislocation of the hip joint, two weeks after closed manipulation. Rotation of the hip was painful, and the total range of motion was less than 75 per cent. of normal.

Fig. 12-B: Retouched photograph of the hip joint, exposed and disarticulated through the anterior iliofemoral approach. The head of the femur showed this impacted stellate fracture, with segmentation of the articular cartilage.

the body of the ischium, and this could be seen in the roentgenogram to be associated with a second fracture, involving the superior ramus of the ischium. In order to disimpact and reduce these fragments, it was necessary to mobilize and reflect the origin of the quadratus femoris. The body of the ischium could then be pulled down; thus the joint cavity was immediately re-established and the head could easily be replaced in the joint. The rim fragment was fixed in position with a single screw. Function of the hip was regained.

FIG. 12-C

Roentgenogram of the hip joint, after the antero-inferior portion of the mushroom-shaped head had been sculptured down to normal size by open operation, two weeks after the original injury.

Trends in Treatment

Before roentgenograms were available, the diagnosis of unreduced or irreducible dislocation of the hip was usually established by innumerable unsuccessful manipulations. In most of the early recorded cases, as well as in many recent cases, not enough data are

FIG. 12-D

Roentgenogram of both hips, two years and eight months after operation. The head of the right femur shows normal density, slight irregularity of the articular cortex, and partial obliteration of the old epiphyseal line. Avascular necrosis of the entire head of the femur probably had not occurred in this case.

supplied to determine the exact reasons for failure of conservative treatment, except that it was usually administered by doctors who had had very little experience with these unusual injuries. Early operative treatment has become common only in recent years. The end results are variable, and sometimes fusion of the joint or arthroplasty is necessary within a few years after the operation.

FRACTURES OF THE HEAD OF THE FEMUR WITH DISLOCATIONS OF THE HIP

Gross fractures of the head of the femur were found in four cases. In Case 24 (Figs. 11-A and 11-B) the antero-inferior portion of the head of the femur, including the fovea capitis femoris and its attachments to the ligamentum teres, remained in the acetabulum, and the hip was dislocated posteriorly. There was very little displacement in two cases of impacted fracture (Cases 25 and 27), but another patient (Case 26) showed an extensive mushroom-shaped deformity of the head. This patient was the only one in the group who showed appreciable limitation of motion of the joint under anaesthesia, after the dislocation had been reduced. Open reduction, therefore, appeared to be indicated in this case in order to reduce the size and diameter of the deformed head and to establish free motion as soon as possible (Figs. 12-A, 12-B, 12-C, and 12-D).

Arthroplasty

The entire joint in Case 26 was exposed by the anterior iliofemoral approach, and dislocation was carried out as in the Smith-Petersen arthroplasty. The head of the femur showed an impacted stellate fracture. The articular cartilage was split into six segments, separated by intermediate areas of raw cancellous bone. The antero-inferior portion of the head protruded from the acetabulum and was crushed against the rim. The ligamentum teres was torn apart and pressed into the substance of the crushed bone in the fovea. The fractured impacted bone, protruding from the head of the femur, was removed with a sharp osteotome, and the head was thus reduced as nearly as possible to the normal size and shape. The bone bled profusely, suggesting that the greater part, or capsular source, of the circulation was intact. After hemostasis had been obtained by warm saline compresses, the head was replaced and was found to revolve freely in the acetabulum.

Trends in Treatment

Gross fractures of the head of the femur, when differentiated from minor bruises, fissures, and subchondral fractures, are rare in dislocations of the hip. Such fractures have been considered very serious injuries by writers who have reviewed the case reports in the literature, but the treatment and results varied according to the exact type of the lesion. In a clean fracture of the inferior portion of the head, when the proximal fragment included the fovea capitis femoris and the blood supply of the ligamentum teres, the fragments sometimes were reduced when the dislocation was reduced; the fracture even healed and good function of the hip resulted. Massive compression fractures, or any type involving the superior portion of the head, healed poorly and resulted in considerable disability. Because the type of injury rather than the treatment determined the results, conservative methods have been adopted in nearly all of the cases reported in the literature in recent years. Arthrotomy with removal of displaced bone fragments was successful when the fracture was limited to the antero-inferior portion of the head, but the operation was naturally ill-fated when the weight-bearing surface of the head was involved. Avascular necrosis with collapse of the femoral head was not a frequent complication in these cases, and was hardly mentioned in the literature. This almost eliminates the possibility that concussion or subchondral compression fractures are etiological factors in avascular necrosis of the femoral head.

COMPLICATIONS

Most of the recent literature on traumatic dislocation of the hip has been devoted to the problems of prevention and treatment of complications. These are usually classified as early or late complications. The following early complications were encountered in this series of cases: retroperitoneal hemorrhage, urinary-tract injuries, thrombosis of the hemorrhoidal veins, thrombophlebitis, sciatic neuritis, and sciatic-nerve palsy. Late complications, encountered within a period of six months to two years after the injury included ossification of the joint capsule, synovitis, avascular necrosis of the femoral head and traumatic arthritis.

Retroperitoneal Hemorrhage

In all cases of comminuted fracture of the acetabulum, blood is probably extravasated into the retroperitoneal space, and may diffuse upward behind the abdominal cavity to the undersurface of the diaphragm. This was observed in one case (Case 20) at autopsy several days after the injury, when the patient died of a concurrent head injury. Similar cases have been described in the earlier literature. Distention, vomiting, and fever, which ensue in the first few days after extensive fractures of the acetabulum, should be treated with this condition in mind. In all cases, a period of traction for five to ten days is advisable, in order to observe the patient for possible head, chest, and abdominal injuries before operative treatment of the hip joint is undertaken.

Urinary-Tract Injuries

Fracture-dislocations of the hip joint, in nine cases in this series, were associated with multiple fractures of the pelvis, such as displaced fragments of the superior and inferior pubic rami, separation of the symphysis pubis, and dislocations of the sacro-iliac joint. Irritation, obstruction, or laceration of the urethra occurred in several cases, and one patient required suprapubic cystotomy. In all cases, the treatment of the urinary-tract injury took precedence over any operative treatment of the skeletal injury.

Thrombosis of the Hemorrhoidal Veins

In one patient (Case 21) with an extensive fracture of the left acetabulum, complicated by dislocation of the sacro-iliac joint on the same side, massive oedema of the rectum and anal orifice developed within a few days after the injury. This was more severe than in any case of hemorrhoids, and the patient had had no previous difficulty of that sort. The oedema and swelling diminished after treatment with hot compresses and disappeared within three weeks, and no other attacks occurred in the ensuing two years. This complication of fracture-dislocation of the pelvis seems not to have been described previously.

Thrombophlebitis

The single patient (Case 23) in this series with severe thrombophlebitis was treated successfully with dicoumarin. This complication has been reported in fracture-dislocations of the hip, but it is probably no more apt to occur in association with such injuries than with other fractures of the lower extremity.

Sciatic Neuritis

Four patients complained of severe pain over the lateral aspect of the lower extremity. There was no motor weakness nor were there consistent changes in sensation in this area, but the pain persisted for several months. These cases were assumed to be instances of minor damage to the sciatic nerve, due to displaced rim fragments or to the dislocation of the head itself. Repeated neurological examinations are necessary to determine whether or not exploration of the sciatic nerve is advisable in such cases.

Sciatic-Nerve Palsy

Permanent damage to the sciatic nerve occurred in four cases in this series with dislocations irreducible by closed manipulation (Table II), but in no simple dislocations [4] or cases without comminution of the posterior rim. One patient had good motor function and sensation in his foot immediately after the accident, pain and foot-drop becoming apparent only after he had been transported in an ambulance for several hours. In another patient, foot-drop developed after several hours of pain, radiating down the extremity, and one manipulation of the dislocated hip. Peroneal palsy developed in two cases only after the hip was subjected to a second manipulation. Only one of the four patients had some return of function of the peroneal nerve. Three showed extreme atrophy of the extremity, and still had complete paralysis of the extensors and evertors of the foot at the end of two years. In all four cases, as in patients with other forms of trauma to the sciatic nerve at the level of the hip joint, the peroneal portion, for some unknown reason, seems more vulnerable than the remainder of the nerve. It is more commonly affected than the posterior tibial portion, and paralysis becomes apparent earlier after the trauma.

The nerve was explored during open operation for an irreducible fracture-dislocation in only one instance (Case 24); but, from observations of the close relationship between the nerve and the displaced rim fragments, it seemed remarkable that any of the cases with comminuted fractures of the posterior portion of the acetabulum escaped sciatic-nerve palsy. Neglected comminuted fractures of the posterior rim heal with the formation of massive deposits of new bone in the soft parts, and there are numerous descriptions of similar operations to free the nerve. Return of function, following injury to the sciatic nerve in the region of the hip joint, is usually slow and incomplete. A number of cases have been reported in which motor function improved over a period of eight years; the Achilles-tendon reflex had not reappeared after ten years; and in some cases the perceptive epicritic functions remained destroyed for even longer periods.

The grave risk involved in injury to the sciatic nerve indicates that all dislocations of the hip, associated with comminuted fractures of the acetabulum, should be reduced by primary open operation, manipulations being entirely avoided. Careful examination of emergency roentgenograms should provide enough information to determine whether or not the acetabulum is too distorted to receive the head of the femur, and whether open rather than closed manipulation is the procedure of choice.

Ossification of the Joint Capsule

In twelve cases of dislocation with rim fracture, two cases of dislocation with fracture of the femoral head, and two dislocations without fracture [4], the roentgenograms showed new-bone formation in the posterior and superior portions of the capsule. Clinically, these patients showed only slight limitation of motion of the hip joint. Almost every one of the other cases in this series showed small deposits in either the femoral or acetabular attachment of the capsule, but these had no detectable effect on the range of motion of the joint.

Synovitis

Minor aches and pains, discomfort in inclement weather, clicking or snapping sensations in the joint, or severe pain when lifting heavy objects were complained of by some patients with ordinary dislocations [4] or with displaced fractures of the acetabulum [5], and by almost all patients convalescing from fracture-dislocations. Many of these patients had a normal range of motion. Some had slight muscle spasm, but the roentgenograms showed flawless joint surfaces and no bone atrophy. These symptoms and findings are tentatively classified as being indicative of traumatic synovitis. This diagnosis is substantiated by the fact that several of the patients later reported that their complaints had

TABLE III

FRACTURES OF HEAD OF FEMUR WITH POSTERIOR DISLOCATION OF HIP JOINT
(MILITARY PERSONNEL)

Case No.	Age	Other Injuries of Ipsilateral Extremity	X-ray Findings	Definitive Treatment	Interval before Weight-Bearing Was Resumed (*Months*)	Complications	Results
24	25	Posterior dislocation of knee	Avulsion fracture of inferior portion of head. Fragment attached to ligamentum teres	Reduction; traction for 8 weeks	12	None	Good. Minc pains occasionally
25	25		Slightly displaced, extensive, impacted fracture of entire head	Reduction; traction for 8 weeks	6	Severe traumatic arthritis	Fair; painfu hip
26	25		Slightly displaced, extensive impacted fracture of entire head. Inferior portion impinged on anterior rim of acetabulum	Arthrotomy, anterior iliofemoral approach. Resection of antero-inferior portion of head	6	Severe traumatic arthritis	Fair; painfu hip
27	25	Fracture of patella	Slightly displaced, extensive, impacted fracture of entire head. Inferior portion impinged on anterior rim of acetabulum	Skeletal traction for 8 weeks	5	Moderate traumatic arthritis	Poor; sever pain

disappeared between one and two years after the injury. Whether others with similar complaints will continue to have symptoms and whether traumatic arthritis will develop five or ten years after the injury, it is impossible to say; but the literature contains no record of cases followed regularly for that length of time.

Avascular Necrosis of the Head of the Femur

Of twenty-seven fracture-dislocations in this series, and fifteen dislocations without gross fractures in a group reported previously [4], avascular necrosis of the head of the femur developed in two cases. Case 15 showed increased density and necrosis of the superior portion of the head, with a line of demarcation separating it from the living bone tissue of the head and neck. Case 18 showed nearly complete disintegration of the bony structure of the head. A review of the operative notes in these cases shows that in Case 15

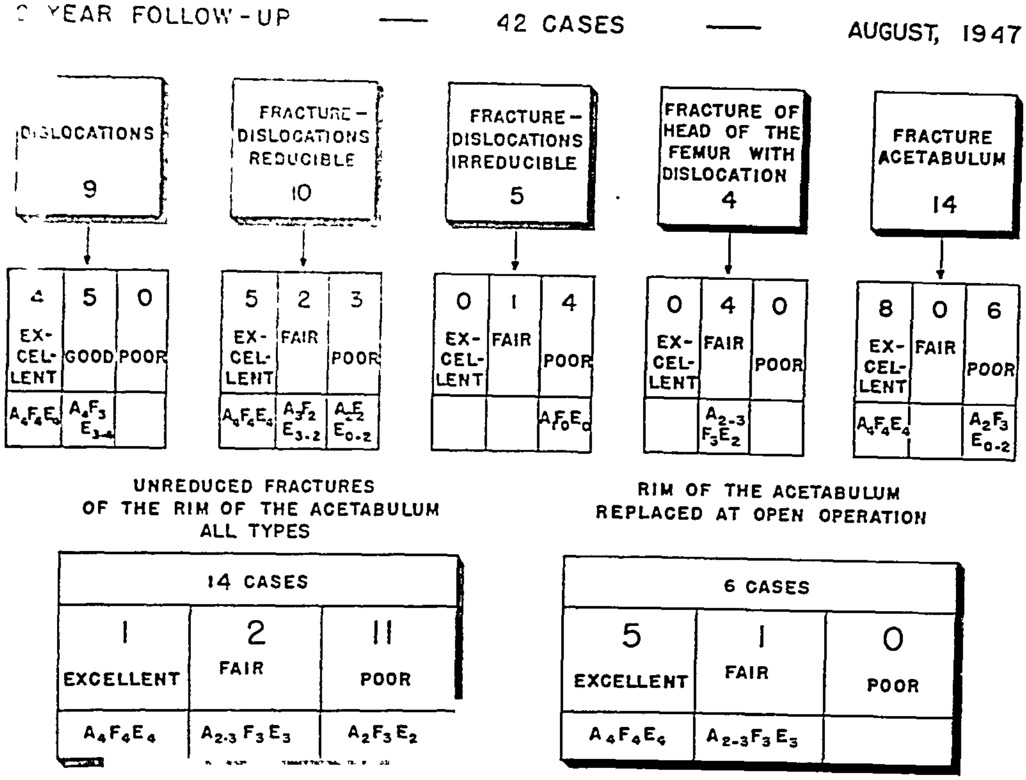

Fig. 13

Chart presenting a comparative analysis of the results, two or more years after the original injury. The complete case records and original roentgenograms were available in every instance. The follow-up data consisted of: (1) numerous personal letters, giving detailed descriptions of the symptoms and joint motion in twelve cases; (2) letters and roentgenograms from the patients or their family physicians in six cases; (3) detailed examinations by Army or private physicians, including measurements of the joint range and repeated roentgenograms in fourteen cases; (4) personal examination of patients by the author in ten cases. The anatomical (*A*), functional (*F*), and economic (*E*) rating was estimated from these data, and graded from 1 to 4, according to the method used on the Fracture Service of the Massachusetts General Hospital. The proportion of patients available for follow-up was: with dislocation, 60 per cent.; with fracture-dislocation, 66 per cent.; with irreducible fracture-dislocation, 87 per cent.; with fracture of the head of the femur, 100 per cent.; and with fracture of the acetabulum, 87 per cent.

a large blood clot was present in the retinaculum, at the margin of the articular cartilage of the head of the femur; and Case 18 demonstrated ecchymosis, new granulation tissue, and thickening of the entire posterior portion of the reflected capsule. These observations are evidence that avascular necrosis is associated with thrombosis of either the retinaculum or the intertrochanteric branches of the medial femoral circumflex vessels. Extensive damage from traction and tearing of the capsule in the posterior intertrochanteric region, in experimental dislocations, has been described by early writers; and, as shown in roentgenograms, by the author in a previous paper [4]. Two cases of isolated fracture of the femur in the same region, without dislocation of the hip, were also reported to have been followed by avascular necrosis.

The microscopic picture of avascular necrosis has been described in detail in specimens from complicated cases of fracture of the neck of the femur, slipped epiphysis, dislocation of the hip, and other types of injury, but the pathogenesis of the lesion is still incompletely understood. The clinical literature which explains the process on the basis of injury of the inadequate blood supply and the results of experimental surgical studies in animals is vast and controversial. The wide scope of subject matter and the limited space in this paper do not permit a complete review. From a recent survey of 135 papers published in the world's literature, the writer interprets the facts as follows: (1) The blood

supply to the superior portion of the head of the femur comes a long distance, through the reflected capsule, from numerous branches of the medial femoral circumflex vessels in the posterior and posterosuperior aspects of the intertrochanteric region. (2) The pathological and roentgenographic appearance of avascular necrosis in man differs from necrosis of the head observed in rabbits, dogs, and goats after surgical cutting of all the arteries and veins which enter the hip joint. Collapse of bone structure occurs relatively early in man, in association with revascularization and replacement of the dead bone; this suggests that the arterial circulation or the venous return was interrupted only temporarily. (3) Avascular necrosis of the hip has been described, not only after posterior dislocations, but also following one case of anterior dislocation and several cases of central fracture of the acetabulum with prolonged intrapelvic protrusion. (4) The incidence of avascular necrosis, following both fractures and dislocations of the hip joint, was estimated to be higher in children and adolescents than in adults; and the reason for this may lie in the larger and more vulnerable vascular network in the reflected capsule in children [6].

There are approximately fifty well-documented cases of avascular necrosis in a total of 270 posterior dislocations recorded in the literature. The lesion was usually observed between six and eighteen months after injury, and has never been reported as developing five or more years later, as supposed by several writers. Serial roentgenograms have not been studied in a large enough group of consecutive cases to determine the true incidence of avascular necrosis in adults.

The present treatment of avascular necrosis of the head of the femur is unsatisfactory for the patient and unpleasant for the surgeon. The diagnosis in this series of cases, as in all the cases on record, was not established until six to twelve months after the injury. Treatment, which consisted in restriction of full weight-bearing, began, therefore, after the roentgenograms had shown some damage to the articular surface of the femoral head. The lack of premonitory symptoms, the difficulties in early roentgenographic diagnosis, and the reluctance of young patients to use crutches under these circumstances, often lead the doctor to relax all restrictions. There is some doubt, however, that the deformity of the head can be entirely prevented by abstinence from weight-bearing, or that "creeping replacement" can restore the joint structure in adults with avascular necrosis as effectively as in children with Legg-Calvé-Perthes disease or in an occasional adult case of impacted fracture of the neck of the femur. In the two cases reported here and in one civilian case [4] which the author has followed closely, there was loss of the bone substance of the superior articular surface of the head, although the patients claim to have used crutches faithfully. Hence, one is forced to assume that a certain amount of the necrotic bone is crushed, independently of weight-bearing, by the action of the pelvifemoral muscles upon the head of the femur, similar to the effects in other ischaemic and destructive lesions of the hip. It is also necessary to emphasize that early abstinence from weight-bearing will not prevent avascular necrosis, but that it only protects a necrotic head from distortion during its replacement by new bone.

Traumatic Arthritis

Degenerative joint changes, secondary to trauma, were observed in twelve cases of fracture-dislocation within two years after injury. This condition could not be differentiated clinically from traumatic synovitis or the early stages of avascular necrosis of the femoral head, but was established by the presence of roentgenographic features, suggesting abnormal wear and tear on defective joint surfaces. These consisted of irregularities in the articular surface opposite the defect on the injured side of the joint. In six such cases there were defects in the posterior rim of the acetabulum, due to unreduced fractures (Cases 8 and 9), to operative removal of fragments (Case 13), or to healed fractures of the head of the femur (Cases 25, 26, and 27). The patients complained of painful crepitations and clicking sensations, and they were uncomfortable when walking on stairs or

lifting heavy objects. Morning stiffness, pain during inclement weather, and inability to stand for long periods without discomfort were also mentioned by some individuals, but these symptoms were difficult to evaluate and were sometimes related to compensation.

Within one year after injury, six patients with extensive fractures of the acetabulum complained of severe pain in the joint and showed increasing limitation of motion; their roentgenograms demonstrated irregularities and subsequent loss of the entire joint space (Table II). These patients were immediate candidates for arthrodesis or mold arthroplasty, the choice of operation depending upon the requirements of the individual patient.

FOLLOW-UP STUDIES AFTER TWO YEARS

The results in nineteen cases of fracture-dislocations of all types after two years (Tables I, II, and III) show that fractures of the articular surface, either of the rim of the acetabulum or of the head of the femur, may lead to serious disability when treated by conservative methods alone. A comparative analysis of these cases and of a control series of nine cases of similar dislocations without fractures [4], and fourteen similar fractures of the acetabulum without dislocations [5], reveals the natural results of healing of these injuries and permits evaluation of current methods of operative treatment (Fig. 13).

Dislocations without displacement of fragments or with minor fractures of the rim of the acetabulum showed results which, as might have been expected, were no different from the best or worst results observed in uncomplicated dislocations. Most of the patients, presumably because of scarification in the synovial membranes and the joint capsule, complained of aching pains, morning stiffness, and snapping of the hip.

Reduced dislocations, with unreduced but significant fractures of the rim of the acetabulum remaining, were followed by degenerative changes in the joint. The late results were usually only fair and were sometimes poor, after surgical removal of the entire posterior rim.

In fracture-dislocations in which a single large fragment of the posterior or superior portion of the acetabulum could be replaced perfectly with its capsular attachment intact, the results were excellent and were equal to the results of uncomplicated dislocation without fracture.

In fractures of the head of the femur which distorted the shape of the head, slowly progressive degenerative changes appeared over a period of two years; but in three cases in this series the joint still showed a useful range of motion. One other patient, whose fracture was limited to the antero-inferior portion of the head, had practically normal function at the end of two years.

Fractures of the rim of the acetabulum without dislocation, as reported previously [5], showed essentially the same results as in uncomplicated cases of fracture-dislocation. In both groups of cases, the integrity of the lunate acetabular cartilage and the rim of the acetabulum is the critical factor in the end results. In matched cases of fractures, treated conservatively and by open operation, good function and little or no disability were shown when the joint surfaces were restored as perfectly as possible, but this could be accomplished only by open reduction. Fractures of the anterior rim and certain types of central fractures of the acetabulum which, even when unreduced, do not involve a significant part of the acetabular cartilage, heal with little or no disability. Comminuted fractures which disrupted the acetabulum, with or without dislocations, produced serious disability and required arthrodesis or arthroplasty in almost every case within two years.

Avascular necrosis of the femoral head occurred within two years in two patients with fracture-dislocation and in one uncomplicated dislocation in an adolescent boy, but in none of the patients with fracture of the acetabulum without dislocation of the head of the femur. Severe traumatic arthritis was present in at least twelve additional cases of l types listed here.

These results are tentative. A longer follow-up period will be required to determine

TABLE IV

SELECTED FRACTURE-DISLOCATIONS OF HIP JOINT AT THE MASSACHUSETTS GENERAL HOSPITAL, 1933 TO 1945

Unit No.	Age	Other Injuries of Ipsilateral Extremity	X-ray Findings	Treatment	Complications	Findings at Follow-up
523309	25		Large single fragment of posterior rim	Open reduction, internal fixation; posterior approach	Sciatic neuritis	Excellent at end of 1½ years
128308	47	Fracture of patella	Comminuted fracture of acetabulum; displacement of posterior rim	Traction	Peroneal palsy	Mold arthroplasty
104952	39		Comminuted fracture of acetabulum; displacement of posterior rim	Acetabuloplasty	None	Hip fusion
331819	25		Comminuted fracture of acetabulum; displacement of posterior rim	Open reduction; replacement of large fragments; removal of small chips	None	Fair. Degenerative arthritis after 6 years

all the possible after-effects of these injuries upon the function of the hip joint. At the end of two years, however, the results in forty-two military cases correspond very closely to those in four similar fracture-dislocations (Table IV), seven dislocations, and seven fractures of the acetabulum [4, 5], studied by the author on the Fracture Service of the Massachusetts General Hospital. These results show that, except in fractures of the posterior rim treated early by primary open reduction and internal fixation, the nature and the magnitude of the traumatic lesion, rather than operative treatment, determine the final outcome. Whether the good results at the end of two years in this series will become poor results after ten years, because of degenerative changes in the joint, remains to be determined by further investigation.

SUMMARY AND CONCLUSIONS

Of twenty-seven fracture-dislocations of the hip joint presented here, fifteen were fractures of the posterior rim, eight were comminuted fractures of the acetabulum, and four were fractures of the head of the femur. Treatment was either conservative or by open operation.

Results at the end of two years, in nineteen patients who could be followed, suggest the following conclusions:

1. Fractures of the posterosuperior rim of the acetabulum with displacement should be repaired as carefully as any other fracture of a weight-bearing joint.

2. Fractures of the posterior rim of the acetabulum, associated with dislocation of the hip, should be treated by cautious closed manipulation, followed by open reduction and internal fixation of the fracture through a posterior approach.

3. Dislocation of the hip joint, associated with comminuted fracture of the acetabulum, should not be subjected to closed manipulation. The only safe and efficient method of treatment is primary open reduction, as soon as the patient is in fit condition for a major procedure. When the goal of the operation is replacement of large fragments and

exploration of the sciatic nerve, the posterior approach is required; when replacement of the head of the femur and erasion of the joint surface in preparation for fusion are indicated, the anterior approach is advisable.

4. Fractures of the head of the femur, except in cases in which it is necessary to reduce the size of the head or to excise the intra-articular fragments, are best treated by conservative methods.

5. Degenerative arthritis may be expected to occur in most cases in which the superior or weight-bearing surface of the head or the superior rim of the acetabulum is defective, and in many cases in which fragments of cartilage and bone were not cleaned out of the joint by open operation.

The diagnosis of avascular necrosis may be disclosed a short time after the injury in cases in which early arthrotomy is indicated. Two patients in this series differed from thirteen others with fresh fractures in that gross hemorrhages were found in the retinacula and the reflected capsule of the hip joint at open operation. One year later, only these two cases showed disintegration of the bone structure of the superior portion of the head of the femur. These observations suggest that avascular necrosis originates in a traction injury and in subsequent thrombosis of the articular branches of the medial division of the femoral circumflex vessels.

NOTE: This work was sponsored by Colonel Mather Cleveland, M.C., Senior Consultant in Orthopaedic Surgery, European Theater of Operations. The follow-up studies were aided by Colonel Michael DeBaky, M.C., Surgical Consultants Division of the Office of the Surgeon General, and Colonel L. T. Petersen, M.C., Surgeon General's Office. Colonel T. B. Quigley, Colonel D. J. Fourrier, Captain Lincoln Ries, and Captain V. Coventry assisted in the treatment of the patients. The follow-up studies of the patients of the Massachusetts General Hospital were made possible by Dr. Edwin F. Cave. Dr. M. N. Smith-Petersen kindly offered valuable suggestions by overseas correspondence in several difficult cases.

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INTRAMEDULLARY PINNING FOR ARTHRODESIS OF THE KNEE JOINT

BY GEORGE CHAPCHAL, M.D., UTRECHT, HOLLAND

From the Orthopaedic Section, Utrecht Surgical University Hospital, Utrecht*

Intramedullary pinning of diaphyseal fractures constitutes an important advance in surgical technique. It has opened many new possibilities in the treatment of fractures, especially those resulting in pseudarthrosis or malunion. This method can also be used in orthopaedic surgery for different purposes, one of which is arthrodesis of the knee joint.

Before testing this technique, we used different methods in arthrodesing knee joints. Each of these methods, even nail fixation, necessitated the use of a large plaster cast to complete the postoperative fixation. All of the methods had to be followed by immobilization of the patient for a period of two or three months. It is true that the most modern technique, with the use of cancellous chips, can shorten the period of immobilization of the patient and give good osseous union of the joint. However, the period of uniting is too long, and the use of a plaster cast is necessary in most techniques.

The disadvantages of a plaster-of-Paris cast are numerous. It does not prevent dislocation of the fragments. If used directly on the skin, the fixation will be good; but the danger of causing a decubitus ulcer is increased, and there is a possibility of circulatory troubles, as well as of paralysis of the peroneal nerve. Postoperative swelling of the extremity makes it impossible to use a narrow cast, so that, when the swelling has disappeared, it is necessary to replace the cast by a new one, to ensure good fixation of the ends. Supervision of the wound healing under the covering plaster is not possible. It is necessary to remove the plaster, or at least part of it, to take out the sutures. This may cause a dislocation of the fragments.

A new method for arthrodesis of the knee was desirable to offset these disadvantages. It should shorten the period of treatment, give better fixation immediately after arthrodesis, and make the use of a plaster cast unnecessary.

Intramedullary pinning of the arthrodesed area of the knee joint is indeed able to give all these advantages. The fixation of the fragments obtained by means of a long intramedullary pin, which enters into the femur and the tibia, is so stable that we are able to omit the plaster-of-Paris cast. The fixation by such a pin is so strong that it will even be possible to shorten the after-treatment to just the period necessary for healing of the operative wound. The primary stability achieved by this pinning is much better than that obtained by nailing the ends with different nails, because of the longer proportion and the better construction of the pin. In other methods where nails are used for fixation in arthrodesis, they are placed in the spongiose tissue of the condyles of the femur and of the tibia. This tissue is soft, so that the nails can change their position as a result of slight trauma. The advantage of using the medullary pin in arthrodesis of the knee is that the pin is fixed in the hard cortex of the bone. Dislocation is then possible only by trauma sufficient to bend the pin or to break the bone.

A further advantage of this method is the fact that we are able to take care of the other joints and the muscles of the extremity. During the patient's rest in bed necessary to the healing of the wound, massage and mobilization of the foot, ankle, and hip are commenced. This enables us to keep the patient fit, so that he will be able to walk from the very day he is allowed to leave his bed. The application of physiotherapy minimizes the possibility of postoperative oedema and muscle atrophy.

* Service of J. F. Nuboer, M.D.

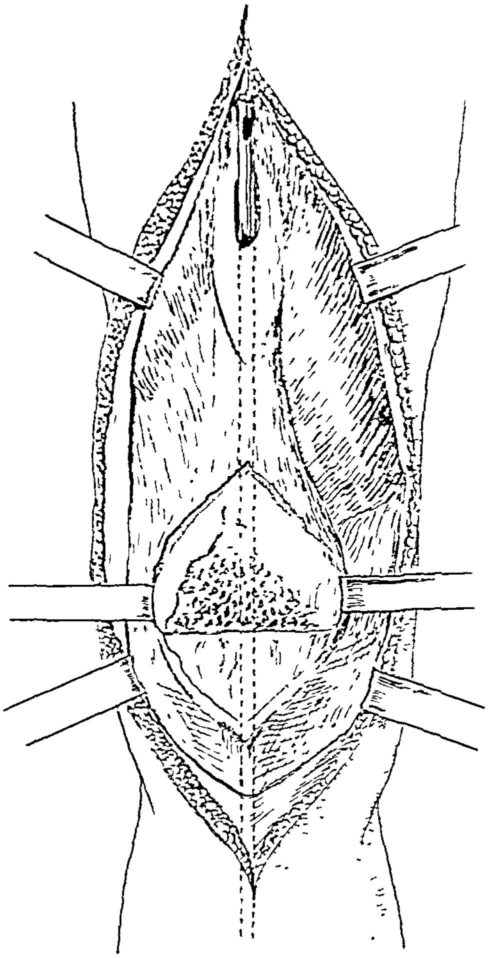

FIG. 1-A

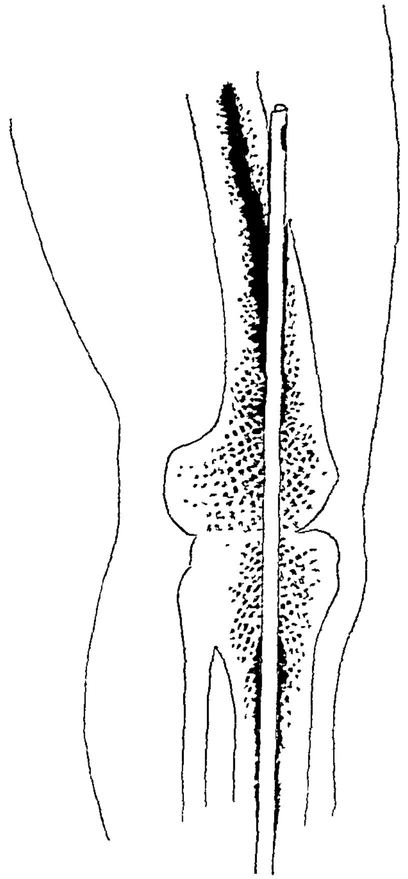

FIG. 1-B

Operative technique of intramedullary pinning for arthrodesis of the knee joint.

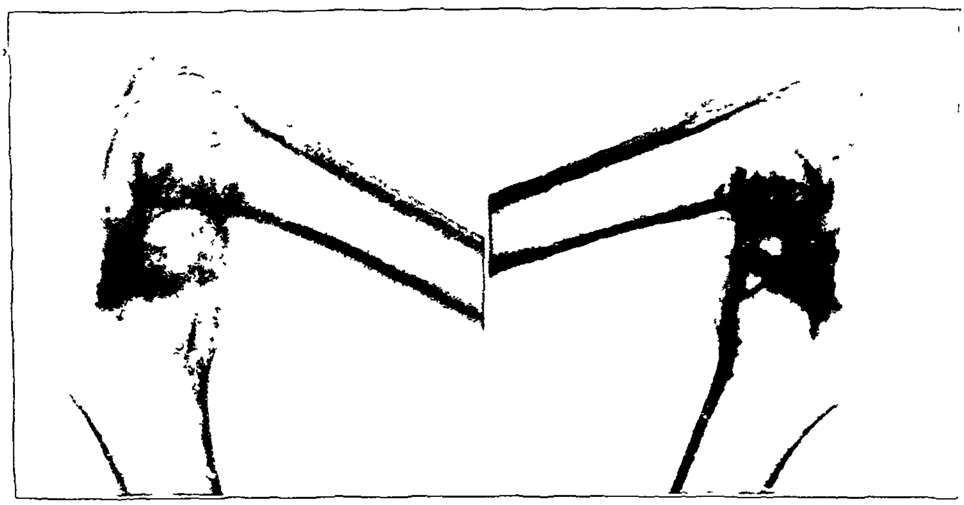

FIG. 2-A

Case 1. Preoperative roentgenograms.

OPERATIVE TECHNIQUE

The operation is performed under general anaesthesia or epidural analgesia. An anterior approach to the knee is chosen. The straight incision of twenty-five to thirty centimeters (ten to twelve inches) runs on the ventral side of the thigh, over the patella to the tuberositas tibiae. By this incision, the femur is exposed and the joint is opened after excision of the patella. The ligaments of the knee are cut, and the surfaces of the joint are exposed by maximal flexion of the knee. The joint cartilage is removed by

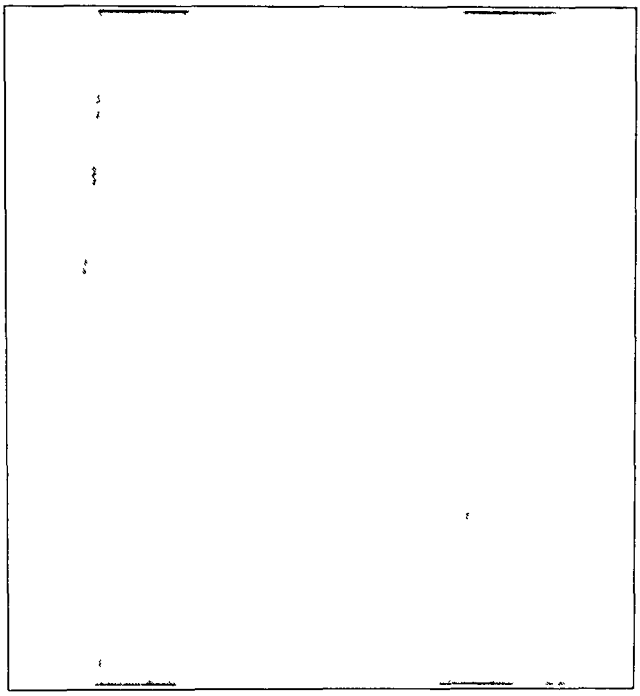

FIG. 2-B

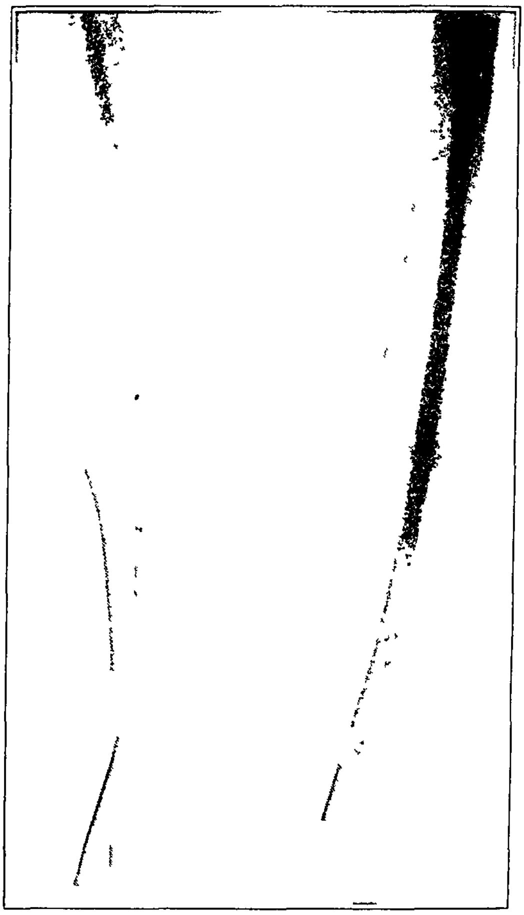

FIG. 2-C

Fig. 2-B. In the left knee, the curved intramedullary pin, as used for pinning of the tibia, broke before osseous union of the pieces occurred, because it was too thin for arthrodesis of the knee joint.

Fig. 2-C: Postoperative control roentgenograms, showing arthrodesis of both knee joints by curved intramedullary pins.

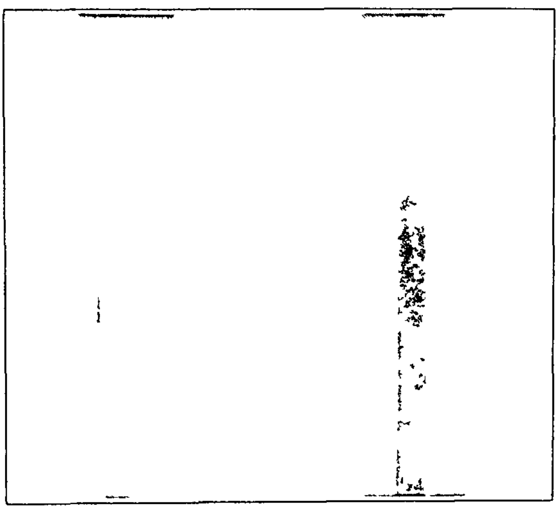

FIG 2-D

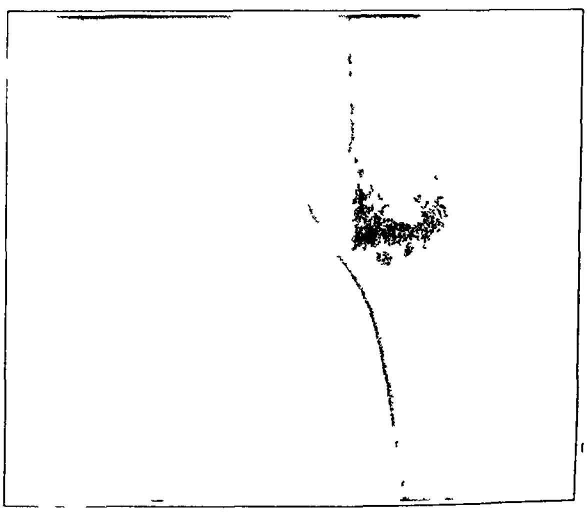

FIG. 2-E

Fig. 2-D: Shows stable osseous union of the arthrodesis in the right knee before removal of the pins (November 5, 1946).

Fig. 2-E: The right knee joint after removal of the pins (November 23, 1946).

sis was performed in 20 degrees of flexion, as the patient was employed in an office and did his work sitting. As a general rule, the flexion of the arthrodesed knee will increase as the distance between the knee and the hole, where the pin enters into the femur, is diminished.

After-Treatment

Excellent stability of an arthrodesis of the knee is obtained by a medullary pin, so that the use of a plaster cast is avoided. It is sufficient to use a bandage on the wound for ten to fourteen days. During this time the patient stays in bed. After the sutures have been removed, he is allowed to leave his bed for increasing periods. Massage should be used for treatment of circulatory troubles, and to avoid postoperative oedema when the patient gets up. After some days the patient is allowed to leave the hospital; at that time he is given a plaster splint, to be used only when walking, and to be taken off when resting. Six weeks later the patient returns for a roentgenographic examination. He is allowed to resume work after three or four weeks more, according to his occupation.

Use of Cancellous Chips

To promote osseous union of the fragments, cancellous chips taken from the iliac bone are sometimes used. They are introduced into the joint before a stable union of the pieces has been caused by the medullary pin, and are fixed in the coagulum obtained by injecting a hemostatic preparation into the hematoma caused in the joint by resection of the cartilaginous covering. The use of cancellous chips marks an important progress in orthopaedic surgery, and their strong osteogenetic power is able to produce a quick osseous union.

FIG. 4-A

Case 4. Preoperative roentgenograms, showing destruction of the knee after shell injury and septic arthritis (November 15, 1945).

FIG. 4-B

FIG. 4-C

Fig. 4-B: Control roentgenograms (March 4, 1947).
Fig. 4-C: Osseous union (September 25, 1917).

INTRAMEDULLARY PINS

Two kinds of medullary pins are used in the treatment of fractures,—thick straight pins for the femur and curved thin ones for the repair of other bones. Case 1 was treated with thin curved pins, as used for fractures of the tibia. They were introduced from a separate incision on the ventral side of the leg, from the tibia, through the knee, into the femur. After a period of rest, the patient was allowed to walk. One knee, arthrodesed by a curved intramedullary pin, showed a favorable result. The other one did not show osseous

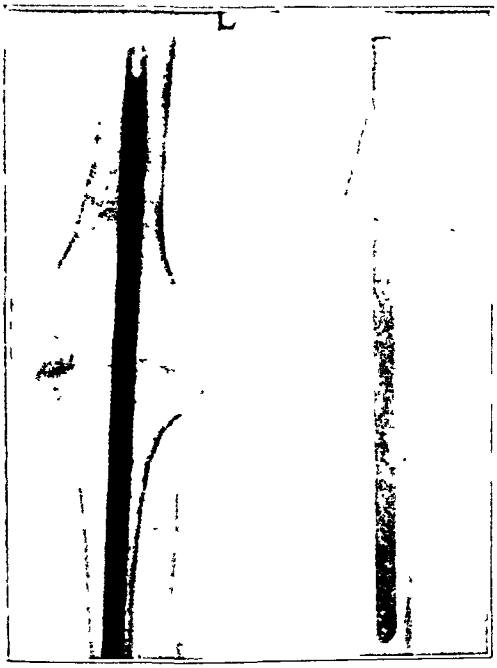

FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 5. Control roentgenograms (March 28, 1947), showing arthrodesis by an intramedullary pin. Note that the knee is in about 20 degrees of flexion.

Fig. 5-B: Shows good osseous union after three months.

union, and consequently the pin broke (Fig. 2-B). This experience suggested the use of stronger pins, introduced as described, from the incision used for the arthrodesis.

The advantage of using a thicker intramedullary pin is clearly evident. It gives better stability and better fixation of the knee. A warning is necessary against the use of pins which are too weak. These pins usually bend when introduced into the medullary cavity. The wall of the pin should be at least two millimeters thick. The pin must be resistant, because in the first period it has to carry the whole weight of the patient and withstand all possible strains.

Removing the Pin

After a period of four to six months, the pin can be removed, if the arthrodesis of the joint is complete. A small incision in the old scar is sufficient to enable one to find the end of the pin and to remove it with the well-known instruments used for this purpose. No difficulties have arisen when this operation has been performed. It is done under local anaesthesia, and the patient is allowed to leave the hospital a few days later. The sutures can be removed at a subsequent date.

In some cases, the pins remained *in situ* for a long period of time without causing any reaction. When the pin was removed, no changes in bone tissue or in the pin were observed. It is possible, therefore, to allow the pin to remain in place for more than six months, without any trouble occurring, if the patient asks for delay in removal.

Indications for Use of a Medullary Pin

The question of when to use a medullary pin is dependent only upon the indications

TABLE I

OUTLINE OF CASES REPORTED

Case No.	Sex	Age (*Years*)	Knee	Diagnosis	Date of Operation	Cancellous Chips	Result
1	F.	47	Right and left	Ankylosis after rheumatoid arthritis Right knee in 50, left knee in 60 degrees of flexion	Feb. 9, 1946 (Right) Feb. 23, 1946 (Left)	Not used Not used	Right—good Left—pin broken before osseous union appeared
2	F.	18	Left	Total paralysis of the limb after poliomyelitis	Apr. 2, 1946	Not used	Good
3	F.	18	Right	Total paralysis of the limb after poliomyelitis	June 6, 1946	Used	Good
4	M.	56	Right	Fibrous ankylosis after shell injury; knee in 150 degrees of flexion	Jan. 8, 1947	Used	Good
5	M.	54	Left	Painful fibrous ankylosis; knee in flexion after rheumatoid arthritis	Mar. 25, 1947	Not used	Good
6	F.	73	Left	Fibrous ankylosis after arthrodesis for arthrosis deformans of the knee; extremely painful	May 30, 1947	Used	Good

for an arthrodesis of the knee. Of course, intramedullary pinning of the knee is not possible in case of inflammatory diseases of the joint, where arthrodesis of the knee is indicated. Here another technique has to be employed. All other cases are suitable for the use of intramedullary pinning, such as arthrodesing the knee for arthrosis deformans, creating a stable limb through arthrodesis of the knee for a total infantile paralysis of the lower limb, or correcting bony ankylosis of a knee joint united in a bad position, as after a shell injury or after gonitis.

All cases of incomplete union or of fibrous ankylosis of the knee joint should be treated by arthrodesis, an intramedullary pin being used, combined with cancellous chips.

It does not seem advisable to pin the knees in growing children, although the author has had no personal experience with the method during this period of life. On the other hand, it is not necessary to wait until the epiphyses have closed. No growth difficulties were seen after pinning in patients eighteen years old. However, this operation should be performed in adults or at the end of the period of growth.

RESULTS

In all but one of the cases where intramedullary pinning of the knee was performed for arthrodesis, the results were favorable. No complications have been observed, except in Case 1, already mentioned, where the curved intramedullary pin, used in the tibia, broke because it was too thin.

No important shortening of the leg was observed, because it was necessary to remove the cartilage of the joint only enough to get good union of the arthrodesis. The patients were permitted to move about early, and no difficulties arose. The fact that a postoperative plaster cast, so often the cause of circulatory trouble, could be avoided, was very satisfactory. The patients walked without pain from the very day they were allowed to get up. After removal of the pins, the stability of the knee and mobility of the patient were not affected. We may conclude, therefore, that this method of arthrodesing the knee gives greater satisfaction than the methods formerly used.

Intramedullary pinning for arthrodesis of the knee joint has been performed seven times on six patients (Table I).

Fig. 1-A

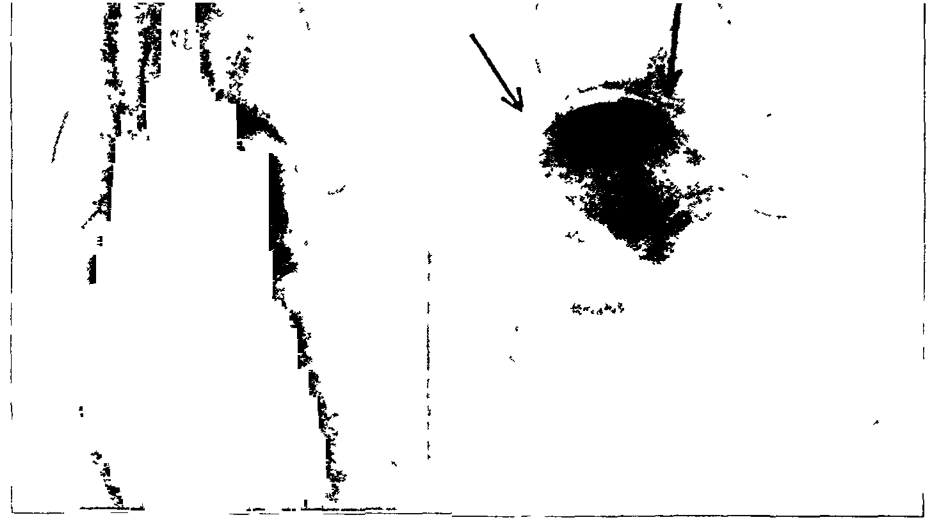

Fig. 1-B

Fig. 1-A: One month after fracture of the neck of the talus with posterior dislocation of the body. The fragments are well reduced, but healing is not complete. There is increased density of the body fragment, extending from the fracture almost to the posterior tubercle.

Fig. 1-B: Eleven months after the injury, the fracture is well healed. Aseptic necrosis of the body is still present to a lesser extent. The density has diminished from the posterior tubercle forward and from the fracture line backward. The subtalar joint is narrowed.

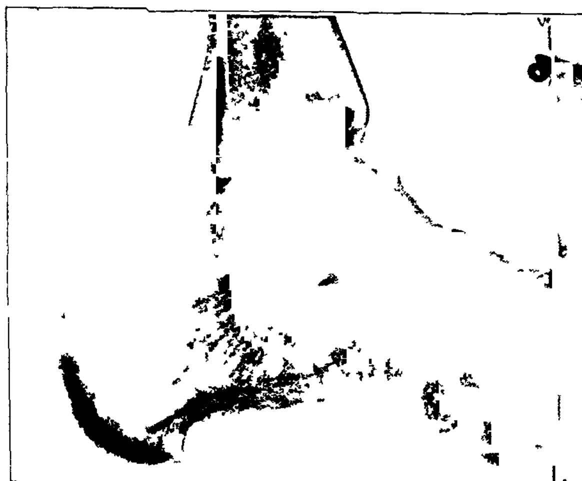

Fig. 2-A

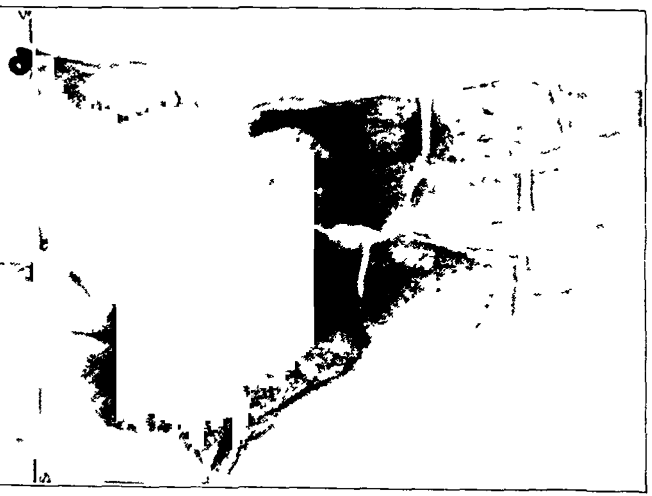

Fig. 2-B

Fig. 3

Figs. 2-A and 2-B: Late result after fracture through the neck of the talus, with dislocation of the head and neck fragment. The head and neck fragment shows the destructive effects of aseptic necrosis. The subtalar joint is narrowed and the talonavicular joint is fused. (These roentgenograms were made available through the courtesy of Leo Mayer, M.D.)

Fig. 3: Fracture of the posterior tubercle of the talus.

FIG. 4

FIG. 5

FIG. 6

Fig. 4: Simple transverse fracture of the body of the talus with no displacement.

Fig. 5: Fracture of the distal tip of the lateral articular surface of the talus. In the lateral view, the fracture line is roughly transverse. In the anteroposterior view, a linear defect is visible on the lateral articular surface.

Fig. 6: Chip fracture of the lateral and superior surfaces of the talus.

FIG. 7

FIG. 8

FIG. 9

Fig. 7. Osteochondritis dissecans of the superior articular surface of the talus.

Fig. 8: In addition to the obvious flap of bone seen in the roentgenogram, there is a complete fracture through the body of the talus, extending downward from the proximal end of the bone flap.

Fig. 9: A triangular bone fragment protrudes from the superior articular surface at the fracture line. This fragment is also protruding medially towards the medial malleolus.

tremity as the fracture of the talus. The fractures healed well and he walked without difficulty; but, after five and one-half months of treatment and observation, he had limitation of motion of the injured ankle, as compared with the normal. The second soldier had an inversion fracture-dislocation of the ankle, the medial malleolus having been fractured longitudinally, the fibula transversely, and the talus through the body. The entire foot and ankle were displaced, so that the talus lay at the medial side of the tibia. The talar fragments were in normal relation to each other and maintained their ligamentous attachments to the rest of the foot. The talus healed well, but, in spite of accurate open reduction and internal fixation of the medial malleolar fragment with a Vitallium screw, this fracture failed to heal and caused considerable disability.

Fractures of the articular surfaces and the posterior tubercle of the talus were not very frequent and ordinarily caused no trouble. The medial articular surface was fractured once in this series, the lateral articular surface (Fig. 5) five times, and the posterior tubercle (Fig. 3) twice. These injuries were incurred in various ways, but the characteristic history was that the ankle had been twisted in a bad landing from a parachute jump or when jumping obstacles. Some of the men described the twist as being in inversion, but most were uncertain as to the exact direction of the twisting force. Immobilization in a plaster-of-Paris boot for three or four weeks produced healing in all but one of these patients, and they were able to return to duty within two months after their injuries. The patient who did not follow the usual course had a comminuted fracture of the lateral articular surface, with a transverse fracture of the medial malleolus of the same ankle. The talar fragments were in good position, but the malleolar fragment was displaced, so that open reduction and fixation with a Vitallium screw were done. Although the reduction was good and healing of the fractures was equally good, the functional result was not entirely satisfactory. At four and one-half months the patient could walk four to five miles daily, but he had some pain when doing so; and, when he tried to run, he lacked power in the "push-off". The range of ankle-joint motion was slightly limited at that time.

Although we have no data as to the outcome in this case, the roentgenographic picture is interesting enough to warrant its inclusion in this survey (Fig. 6). While doing a rope climb, this patient fell about twenty feet and injured his ankle. The roentgenograms showed a chip fracture of the lateral and the superior articular surfaces of the talus. There was also some instability of the talus, as shown by a lateral tilt, but further discussion of the instability does not pertain to this report. If this fracture had failed to heal and the fragment had become sclerotic, it might be difficult to distinguish it from osteochondritis dissecans of the superior articular surface of the talus (Fig. 7). Unfortunately, this patient was lost sight of, and the final result is not known.

The presence of displaced bone fragments from the superior articular surface of the talus did not necessarily indicate a poor prognosis. Two patients were seen in whom this problem presented itself. The exact mechanism of the injury was not known, but one patient struck his foot on the rim of a jeep, from which he was thrown in an accident. The talus was fractured transversely across the body, and the major fragments remained in perfect alignment (Fig. 8). However, a large rectangular flap of articular cartilage and subchondral bone was pried up from the superior articular surface of the distal fragment. Closed manipulation was unsuccessful in reducing this fragment; and six days later an incision was made, the fragment was replaced, and the foot was dorsiflexed until the fragment passed beneath the anterior margin of the distal articular surface of the tibia. This held the fragment in position, and a plaster boot was applied for two months after operation. Further convalescence was uneventful. Six months after the injury, this man reported that he was doing a full day's work at hard, manual labor, and that he had walked as far as twenty-five miles in a single day without difficulty. Examination at that time showed the ankle to be normal in all respects. There was no swelling and no limitation of motion.

The other patient had a transverse fracture of the body of the talus, but the distal fragment and the foot were dislocated distally and medially. When the displacement was reduced, a triangular fragment projected from the superior articular surface (Fig. 9). This fragment from the fracture site was so placed that the projection would have undoubtedly blocked dorsiflexion of the ankle, had it been permitted to heal in that position. Therefore, a month after the injury, the fragment was removed, and immobilization was continued for an additional two months. Five and one-half months after the injury, the patient had no complaints when participating in moderately strenuous activities. He had a complete range of motion, with no pain on motion of the ankle when he was not bearing weight; but there was slight soft-tissue thickening about the ankle, and running caused some pain. This experience indicated that it was best to replace dislocated fragments when possible. These fragments can heal, and, while there is danger of aseptic necrosis, it is not inevitable and the risk is worth taking. In each case, inspection of the joint at operation showed that the surface area of the articular cartilage covering the displaced bone fragment was larger than the surface area of subchondral bone, seen in the roentgenogram. The additional cartilage was avulsed with the portion attached to the bone fragment.

Eight patients had fractures through the body, close to its juncture with the neck, in which the major fragments were displaced or in poor alignment. In five patients the distal fragment was displaced with the rest of the foot, thereby causing a dislocation of the posterior portion of the subtalar joint. None of these five could describe accurately the exact mechanism of injury, although all had been injured in hard parachute landings on irregular ground (Fig. 10-A). The body of the talus remained within the ankle mortise and was rotated downward in equinus; the distal fragment and the foot were displaced distally, sometimes medially, and the superior articular surface of the distal fragment was usually elevated above the superior articular surface of the proximal fragment, indicating that the fracture was due to dorsiflexion.

Fig. 10-A

Characteristic displacement of the posterior subtalar joint, with fracture of the body of the talus.

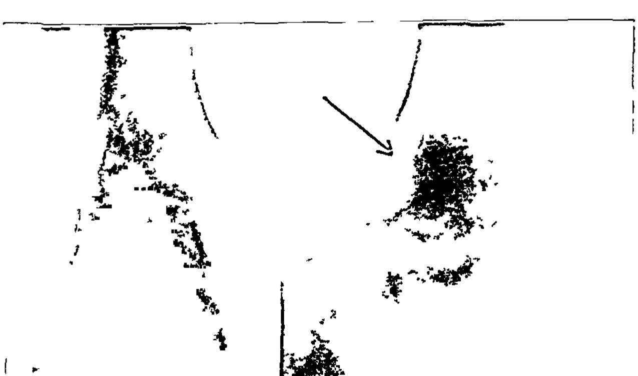

Fig. 10-B

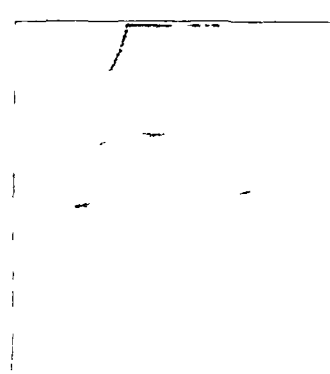

Fig. 10-C

Fig. 10-B: Prominence of superior articular surface at the level of the fracture, which blocks dorsiflexion. This is not due to compression of the proximal fragment, but to inadequate reduction of the distal fragment.

Fig. 10-C: Oblique view of the same patient distorts the contour of the talus, and does not clearly show the prominence of the superior surface of the distal fragment.

Fig. 11

Fig. 12

Fig. 13

Fig. 11: Slight prominence of distal fragment, insufficient to block dorsiflexion and causing no symptoms.
Fig. 12: Minimal downward displacement of the distal fragment. The functional end result was excellent.
Fig. 13: Lateral and anteroposterior views of fracture of the talus with posterior dislocation of the body behind the tibia.

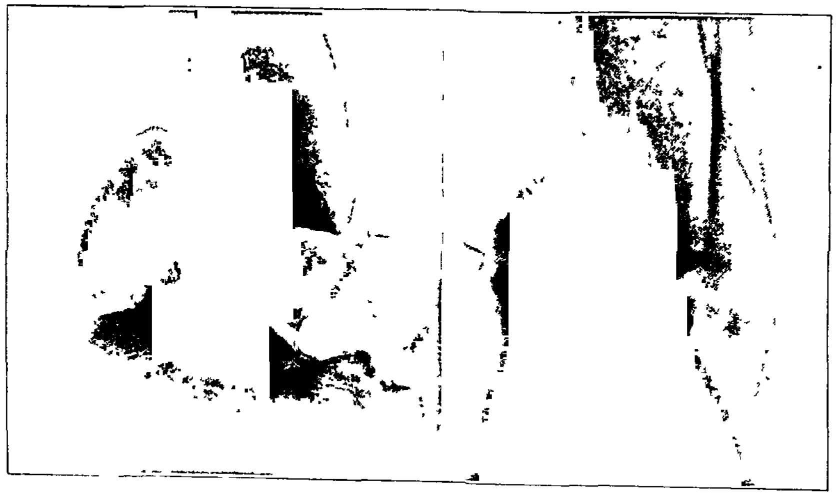

Fig. 14-A

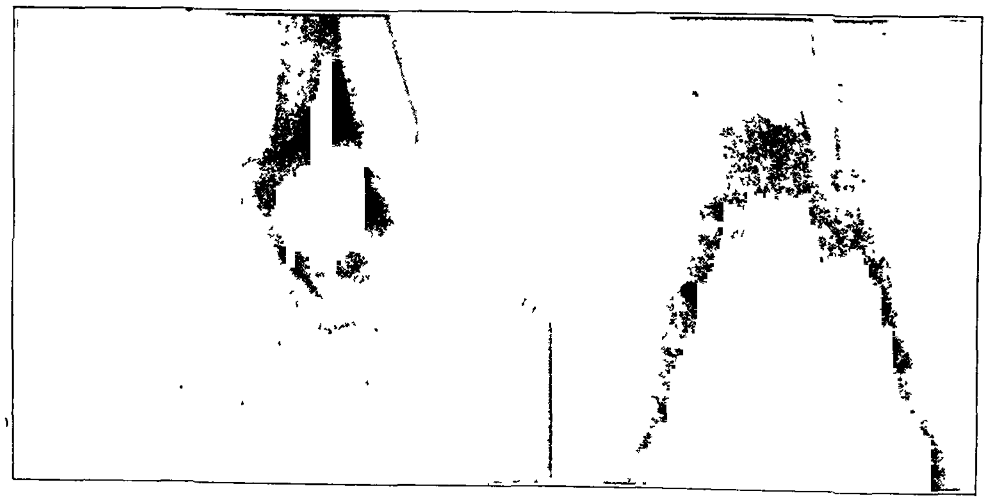

Fig. 14-B

Fig. 14-A: Fracture-dislocation of the talus with marked comminution of the medial malleolus of the tibia.
Fig. 14-B: Same case, nine months after the fracture. Note the increased density of the central part of the body, obliteration of the subtalar and talonavicular joints, irregularity of the medial malleolus, and marked destruction of the ankle joint.

The displacement could be reduced by closed manipulation. General or spinal anaesthesia was used. The knee joint was flexed to 90 degrees; the foot was held in equinus; and traction was exerted by grasping both the heel and the fore part of the foot, countertraction being maintained under the thigh. During this manoeuvre, pressure was exerted with the thumb on the sole of the foot at the level of the displacement, in an attempt to lever the fragments into position. Following the manipulation, a plaster boot was applied with the foot in the neutral position or in slight equinus. Watson-Jones has advocated that the foot be kept in equinus to prevent recurrence of the displacement. However, once properly reduced, the fragments are stable and no ill effects were noted that could be attributed to the position of the foot in plaster. With the foot in the neutral position, ultimate rehabilitation was speeded considerably. When the fragments were replaced, they united readily during immobilization in a plaster boot for ten to twelve weeks, and in no case did aseptic necrosis appear.

Although, in other locations, slight displacement of the fragments may be of little consequence, in the talus it may be the source of very serious disability. In one case (Fig. 10-B), the reduction was incomplete, and the superior articular surface of the distal fragment was permitted to project only slightly above that of the proximal fragment. However, it was enough to abut against the anterior margin of the distal articular surface of the tibia, and the foot could not be brought into complete dorsiflexion because of the bone block. This case called to our attention the absolute necessity of taking at least one true lateral projection of the roentgenogram. An oblique view (Fig. 10-C) failed to demonstrate the displacement, and it was missed until six weeks after the fracture, when true lateral views were taken. In one case (Fig. 11), the upward displacement was so slight that the distal fragment did not interfere with dorsiflexion; and in another (Fig. 12), with minimal downward displacement of the distal fragment, healing and function were excellent. In summary, it can be said that a good result can be expected in this type of fracture if the fragments are accurately replaced.

The cases that did most poorly were three patients who had transverse fractures of the body of the talus, in which the proximal fragment was displaced posteriorly behind the tibia (Fig. 13). The displaced fragment was rotated 90 degrees, so that it lay at right angles to its usual position, with the fractured surface facing laterally and the posterior tubercle facing medially. All the patients described their injuries as being of such a nature that the force of the trauma was applied to the plantar surface of the fore part of the foot, bringing it into marked dorsiflexion. In this manner the anterior lip of the tibia acted as a wedge, across which the talus was fractured close to the juncture of its neck and body (Fig. 15). As dorsiflexion continued, dislocation occurred in the posterior portion of the subtalar joint; the heel was displaced forward; the posterior capsule of the ankle joint was ruptured; and, according to Watson-Jones, the sustentaculum tali passed under the medial tubercle of the talus. When dorsiflexion stopped and the foot returned to the neutral or equinus position, the medial tubercle was caught behind the sustentaculum tali, and the body of the talus was pushed posteriorly into the space behind the tibia, between the tendons of the flexor hallucis longus and the flexor digitorum longus, as demonstrated by Gibson and Inkster. This displacement was particularly difficult to reduce.

Watson-Jones reported a technique of reduction of these fractures by closed manipulation. The calcaneus is distracted from the tibia by traction on the calcaneus, with the foot in equinus. The proximal fragment is then replaced by the exertion of pressure with the fingers. If this is inadequate, a metal pin is used to manipulate the fragment into position. We were unsuccessful in our attempts to reduce these fractures by closed means, and did not use the pin method, because it was felt that the pin would cause additional injury to the already damaged articular cartilage. Operation was then performed to replace the fragment. An incision was made on the lateral aspect of the ankle, and, even with the joint exposed, it was difficult to replace the fragment. The heel had to be distracted

from the tibia by traction. In some cases manual traction was insufficient, and a bone hook had to be applied to the dorsum of the calcaneus. If the bone hook does not provide enough traction, a Kirschner wire in the calcaneus can be used. After reduction, the joint was inspected, and all free fragments were removed or replaced. Although screw fixation, from the outer surface of the distal portion of the neck into the body of the talus, was used in the earlier cases, it was found to be unnecessary, and no displacement occurred when it was not used. Because subtalar motion was subsequently impaired and the roentgenograms showed narrowing of the subtalar joint in all these cases, we now believe, with Schrock and Miller, that a subtalar fusion should be combined with the open reduction. This would stabilize the joint to eliminate a source of disability, and would also *provide an additional source of circulation to the portion of the talus that is most likely* to undergo aseptic necrosis. In the cases described here, when aseptic necrosis occurred, weight-bearing was not permitted until reossification had taken place.

In spite of accurate open reduction, the end results in these three cases were bad. One patient (Fig. 14-A) had a badly comminuted fracture of the medial malleolus, in addition to the fracture-dislocation of the talus. The outlook from the beginning was

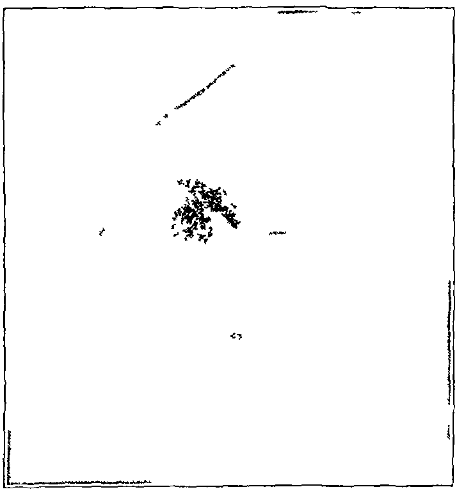

Fig. 15

Fig. 16

Fig. 15: Lateral view of a normal ankle, the patient bearing weight with the foot dorsiflexed, to demonstrate the mechanism of fractures of the body and neck of the talus.

Fig. 16: Six months after open reduction of a fracture of the talus with posterior dislocation of the body. There is increased density of the body, as compared with the neck and head and the posterior tubercle. The fracture is healed.

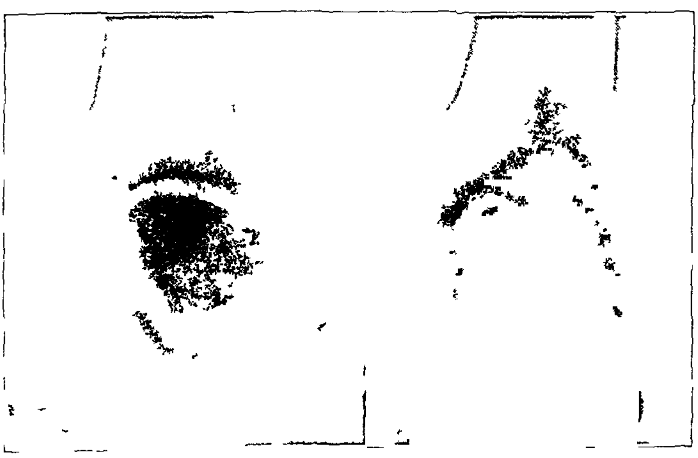

Fig. 17

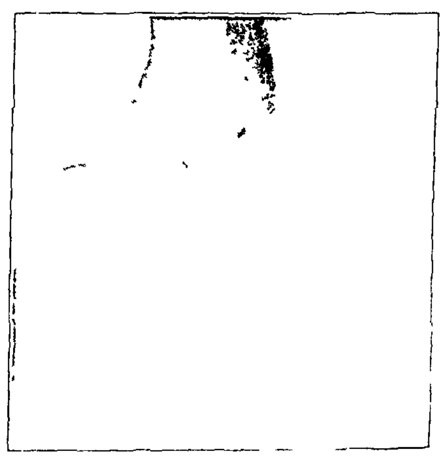

Fig. 18

Fig. 17: Traumatic arthritis of the ankle after fracture of the talus.

Fig. 18: Late result after astragalectomy for fracture-dislocation of the talus. The functional result was poor. (This roentgenogram was made available through the courtesy of Leo Mayer, M.D.)

unfavorable, and primary arthrodesis should have been carried out. The talus was accurately reduced by operation; the medial malleolus was not. Necrosis developed in the proximal fragment, due to circulatory deficiency, and a wound infection was superimposed on this. The wound continued to drain, and much of the superior articular surface of the talus became sequestrated (Fig. 14-B). Ten months after reduction, the necrotic bone was removed and arthrodesis was performed. The second patient did not have so great a degree of aseptic necrosis (Fig. 16); but six months after his injury he still had pain, swelling, and considerable limitation of ankle and subtalar motion. He will undoubtedly need an arthrodesis at a later date. In the third case, the proximal fragment was displaced medially between the tendons of the flexor hallucis longus and the flexor digitorum longus (Fig. 13). The pressure on the tendons caused plantar flexion of the toes. At operation, through a medial approach, it was seen that the posterior tibial vessels and nerve had been pressed against, but had not been interrupted. After the operation, the patient lost sensation in the entire sole of the foot and inner aspect of the ankle, and the intrinsic muscles of the foot were paralyzed. In the year following his injury, sensation gradually returned to the sole of the foot, leaving only a small anaesthetic area under the heel and on the medial side of the ankle. Some strength had also returned to the intrinsic muscles of the foot. Aseptic necrosis of the body of the talus also developed in this patient; this condition had partially healed at the end of a year (Figs. 1-A and 1-B). In a letter received a year and a half after his injury, this patient stated that he still had swelling, pain, and limitation of motion sufficient to make him limp. Ankle fusion will probably be necessary at some future date.

The procedure of arthrodesis of the ankle joint was not done as a primary operation in this series. We now believe that, when a fracture causes such distortion of the component bones of the joint that accurate alignment cannot be restored, the joint should be arthrodesed at the first operation. If treatment has been unsuccessful, the talus has become misshapen, and hypertrophic changes have developed in the ankle joint (Fig. 17), the only treatment available that offers hope of a painless and stable ankle is arthrodesis.

No astragalectomies were done in this series. The operation has been recommended by Graham and Faulkner for badly displaced and comminuted fractures of the talus, but it does not offer the same assurance of a good result that arthrodesis does. Although motion may exist in an astragalectomized joint, the joint is usually painful and unable to withstand heavy work (Fig. 18). The patients reported to have been helped by astragalectomy following trauma were usually those in whom ankylosis supervened.

SUMMARY

1. The circulation to the talus is deficient, but clinical evidence would indicate that the blood supply enters through the many ligamentous attachments of the talus, and not solely through the articular branch from the dorsalis pedis artery, which enters the superolateral aspect of the neck of the talus.

2. In fractures without displacement, whether of the body or of one of the articular surfaces or processes, the prognosis is good. Aseptic necrosis did not develop in these cases and, after adequate immobilization in a plaster boot, complete function was restored.

3. When the fracture is comminuted and a fragment is displaced in such a manner that it will interfere with motion, the fragment must be removed or replaced. Replacement is preferable for, if the fragment unites, the result is likely to be better.

4. Displaced fragments must be reduced accurately. When there has been a partial forward displacement of the posterior portion of the subtalar joint, closed reduction is feasible and usually successful. It is extremely important that the reduction be checked by a true lateral roentgenogram, to determine whether or not the superior articular surface of the talus is in satisfactory alignment. With adequate immobilization and accurate reduction, there is every likelihood of a good result without aseptic necrosis.

5. When the dislocation was complete and the talar body was displaced behind the tibia, attempts at closed reduction were unsuccessful in our hands. In spite of accurate open reduction, the results were poor. Aseptic necrosis appeared in all three of these cases. Subtalar arthrodesis should be done at the time of open reduction. This will stabilize the damaged joint and will increase the circulation to the proximal fragment. If there is an associated fracture of the medial malleolus, or so much destruction of articular cartilage that the prospect of a good result is poor, arthrodesis of the ankle joint should be done at the first operation.

NOTE: This work was done on the Orthopaedic Section of the Army Service Forces Regional Hospital, Fort Benning, Georgia, Colonel Chauncey E. Dovell, commanding. The author wishes to express his appreciation to Major Roy Ciccone and the other members of the Orthopaedic Section for their help in treating and observing these patients, to Colonel E. R. Bowie and the X-ray Department for their splendid cooperation, and to the Army Field Printing Plant at Fort Benning for many of the reproductions.

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A STUDY TO DETERMINE THE ANGLE OF ANTEVERSION OF THE NECK OF THE FEMUR

BY PAUL C. KINGSLEY, M.D., AND K. L. OLMSTED, M.D., ANN ARBOR, MICHIGAN

From the Division of Orthopaedic Surgery, Department of Surgery, University of Michigan School of Medicine, Ann Arbor

This study was initiated to determine, if possible, the true angle of anteversion of the neck of the femur. In the past there has been a wide difference of opinion as to this measurement, and more recently Campbell stated that, normally, anteversion of approximately 25 degrees occurs. The authors believe this figure to be far greater than the average. Anteversion is a very important factor in the etiology of congenital dislocation of the hip, and it is hoped that this study may aid in further research on this subject.

In the foetus, during the first half of pregnancy, the axis of the neck of the femur and that of the shaft lie in parallel planes; thus, during this stage of development, the angle of anteversion is 0 degrees. At birth, a torsion of the neck on the shaft has taken place which, according to Le Damany, is from 30 to 50 degrees. This marked increase in torsion is attributed to the fact that, during the second half of pregnancy, acute flexion of the hip takes place; and there is difficulty in its adjustment within the uterine cavity. The pressure of the uterine muscles against the flexed thigh produces a force of internal rotation on the femoral shaft, causing anteversion of the femoral neck. After birth, because of extrinsic factors such as muscle pull and capsular restriction, the anteversion is partially rectified, to the extent of about 15 to 30 degrees. Le Damany believed that, at birth, anteversion of the neck of the femur was normally found to a high degree, this being somewhere between 30 and 50 degrees; and that during childhood this angle gradually diminished, until in the average adult it had decreased to 12 degrees.

In studying this problem, the authors have attempted to find the average angle of anteversion of both the adult and the infant femora, to discover what variations exist between the right and the left femora, and to evaluate any marked variations in the angle of anteversion of the femur in the two sexes. This study was carried out in the Anatomical Laboratories of the University of Michigan, where dry anatomical specimens were measured. Measurements were taken on 630 individual adult femora, forty-five known pairs of adult femora, and thirty-two pairs of femora of infants and children of known age.*

The angle of anteversion of the neck of the femur varies through a wide range, thus making it extremely difficult to determine just what can be considered normal. Testut states that Broca found this variation to be from 2 degrees to 38 degrees; since that time, others have found it to range from 25 to 41 degrees. The mean average, according to various authors [3,5–11], ranges from 11.9 to 25 degrees.

The authors' series of measurements of 630 femora show this same wide range of variation. In the adult femur, the minimum angle found was minus 20 degrees and the maximum was 38 degrees, while in the foetal and infant femora the range was between minus 10 degrees in a five-months' foetus and 64 degrees in one stillborn foetus.

Various methods have been used by each investigator to determine this angle, and for this reason it is difficult to compare the findings in our series with those of others; but the authors feel that sources of error are present in the methods previously used, which account for the wide variations given for the mean average angle [5,12].

We feel that the angle of anteversion is that formed by the juncture of two planes.—

* The authors are greatly indebted to Rollo E. McCotter, M.D., Director of the Anatomical Laboratory, whose willing cooperation and helpful suggestions have made this study possible.

one passing through the long axis of the shaft of the femur, and the other passing through the long axis of the neck of the bone as viewed from above. The following is the method used to determine this angle: The femur was placed on a smooth, level, horizontal surface, so that it rested on three points,—namely, the posterior aspects of the two femoral condyles and the posterior aspect of the greater trochanter. The angle of obliquity of the shaft was disregarded, because this is normally extremely small; and it has previously been shown [7] that, in disregarding this angle, an error of only 0.2 degree will result in the determination of the angle of anteversion. Therefore, the authors felt justified in ignoring the angle of obliquity in this study.

Fig. 1-A

The greatest difficulty encountered was in the determination of the true longitudinal axis of the neck of the femur. It was felt that the head of the femur could not enter into this determination, as Pearson and Bell imply in their term "capito-collar" axis, because of the fact that the head is not centered on the neck of the femur. In this study the head was found to be displaced, either anteriorly or posteriorly, in 68.7 per cent. of all femora. This was determined by actual measurements; therefore, we did not use any point on the head to aid in determining the axis of the neck, as had been done previously by Pearson and Bell and by Parsons.

The authors felt that if the exact center

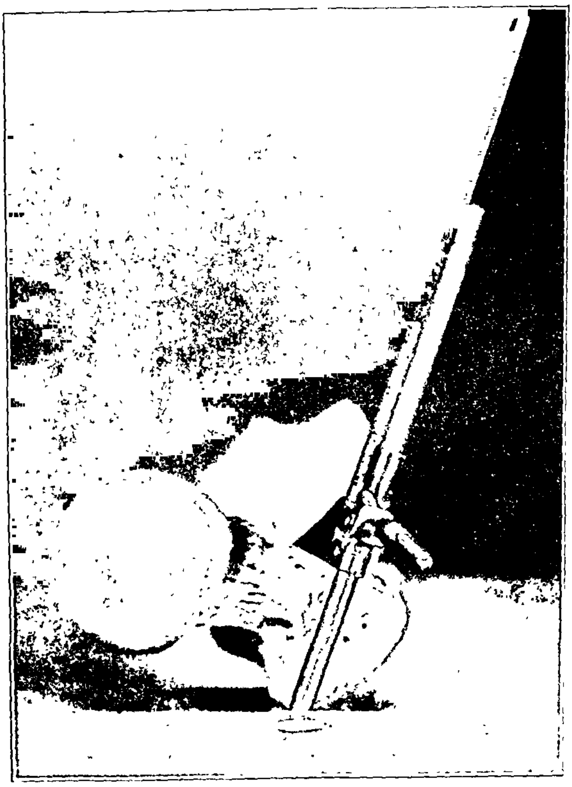

Fig. 1-B

Fig. 1-C

The three positions of the height gauge show how the exact center points, on the neck of the femur, were determined.

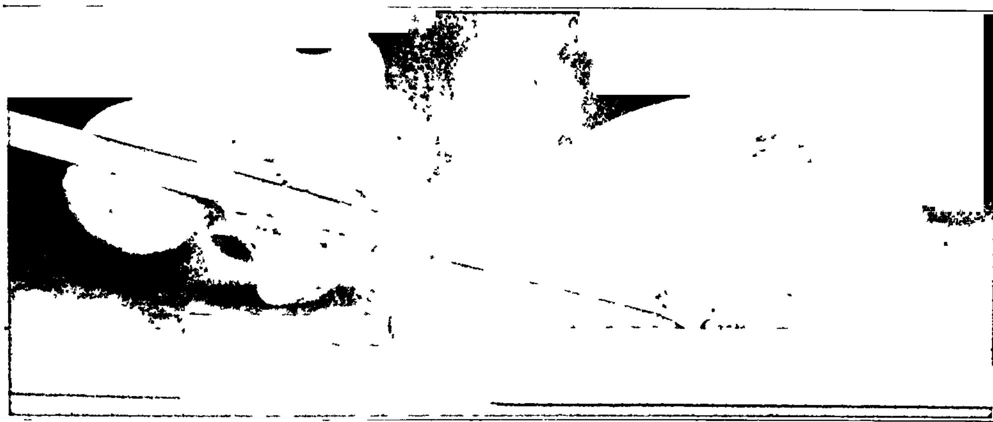

FIG. 2

Protractor in position to read angle of anteversion.

of the neck, between its anterior and posterior surfaces, could be determined at two different points on the neck, as viewed from above, a line connecting these two points would give the true long axis of the neck. If this line were then continued to the surface supporting the bone, an angle would be formed; and it was felt that this presented the true angle of anteversion.

Difficulty was encountered with those femora showing a reverse angle, or an angle of retroversion, owing to the fact that they rested on the posterior aspect of the two condyles and the head, rather than on the posterior surface of the greater trochanter. Therefore, it was necessary to elevate the bone on two small, smooth blocks, one centimeter in thickness; one was placed beneath the condyles and the other beneath the greater trochanter, thus allowing the head, in the case of a reverse angle, to lie actually below the level of the supporting surface of the femur. It was noted occasionally that the bone would rest on the lesser trochanter rather than on the greater trochanter; but, by shifting the block slightly, it was still possible to make the greater trochanter the proximal supporting point of the bone.

The two center points on the neck, between its anterior and posterior surfaces, were determined by the use of a height gauge (Figs. 1-A, 1-B, and 1-C). The vertical rod which held the pointer and millimeter scale was fastened to its base by means of a bolt. Thus this rod was movable; it could always be set perpendicularly to the longitudinal axis of the neck of the femur and a true reading obtained. The millimeter scale was fastened to the pointer, which was free to slide up and down on the vertical rod, and thus a direct reading could be made from a fixed point on the rod. Two points were marked on the neck of the femur—one distally and the other proximally—and, with the height gauge, two readings were made at each of the two selected points. The readings were taken, one at the posterior surface and the other at the anterior surface of the neck; by subtracting one reading from the other, the anteroposterior diameter of the neck at that given point was determined in millimeters. Exactly one-half of this diameter was determined, and the height gauge was set at this figure; thus was obtained the true center of the neck in its anteroposterior diameter at that given point. The procedure was repeated at the second selected point on the neck, and the center at that point was obtained. These two points were carefully marked on the femoral neck.

A protractor (Fig. 2) was devised, by which the angle of anteversion could be read directly, after the two center points of the neck had been determined. A transparent celluloid protractor was mounted on a base, so that it would read from the same height as that of the blocks upon which the femur rested. A long metal arm was attached at the

TABLE I

MEAN AVERAGE ANGLES OF ANTEVERSION FOR 630 ADULT FEMORA

	Left (Degrees)	Right (Degrees)	Average (Degrees)
		Male Femora	
Mean	7.42	8.42	7.94
Range	−17 to 31	−15 to 33.5	−17 to 33.5
		Female Femora	
Mean	7.55	8.71	8.11
Range	−14.5 to 38	−20 to 30	−20 to 38
		Total of Male and Female Femora	
Mean	7.47	8.54	8.021
Range	−17 to 38	−20 to 33.5	−20 to 38

center point of the base of the protractor, and this arm served to connect the two center points, marked on the neck of the femur. The angle thus formed (Fig. 2) was considered to be the true angle of anteversion and was read directly from the protractor, the eye being on a level with the axis of the neck.

Six hundred and thirty femora were studied, and the angle of anteversion was measured. In this study, as in those of the past, there was found to be a very wide range for this angle, but the average was determined to be 8.021 degrees. An attempt was made to classify the specimens according to sex, but, because no previous record concerning the specimens was available, it was possible to classify them only as to male and female types. The female type was considered to be that in which the entire bone was smaller,—the diameter of the head was small, the muscle attachments were less prominent, and the bone was lighter in weight. A further classification was made by separating the specimens into right and left femora, in order to determine whether or not some variation would be shown in the opposite femora of known pairs.

Three hundred and eighty femora of the male type were measured, and, of these, 184 "lefts" showed an average angle of anteversion of 7.422 degrees. The 196 "rights" showed

TABLE II

MEAN AVERAGE ANGLES OF ANTEVERSION FOR THIRTY INFANT FEMORA

	Left (Degrees)	Right (Degrees)	Average (Degrees)
		Male Femora	
Mean	24.3	20.9	22.6
Range	−5 to 45	−10 to 39	−10 to 45
		Female Femora	
Mean	25.3	27.1	26.2
Range	−6 to 64	−6 to 48	−6 to 64
		Total of Male and Female Femora	
Mean	24.8	24.0	24.4
Range	−10 to 48	−6 to 64	−10 to 64

TABLE III

MEAN ANGLES OF ANTEVERSION IN THIRTY-FOUR FEMORA OF CHILDREN *

	Left (*Degrees*)	Right (*Degrees*)	Average (*Degrees*)
Mean	16.4	17.9	17.2
Range	−4.5 to 38	0.5 to 33	−4.5 to 38

* The ages ranged from 2 to 15 years

this angle to average 8.423 degrees. Two hundred and fifty specimens comprised the group of the female type. Of this group, 121 were lefts and the average angle was found to be 7.549 degrees, while in the group of 129 rights it was 8.707 degrees. Of the total specimens of the male type, the average angle was 7.938 degrees, whereas this angle in the entire group of the female type was 8.107 degrees. Taking into consideration the entire group, composed of both male and female types, we found that in 305 lefts the angle was 7.472 degrees, while in 325 rights it was 8.536 degrees. Thus the right femur has a slightly greater angle of anteversion than that seen in the left, and in the female type this angle is slightly greater than in the male (Table I).

In infants and children the angle of anteversion is much greater because, as stated previously, at birth a high degree of anteversion is normally seen in the femoral neck, due to the position attained by the foetus *in utero*, a condition which is gradually rectified during childhood. The present series of fifteen pairs of infant femora is small, but nevertheless does bear out this fact (Table II). The left femur of the male had an average angle of 24.3 degrees; the average for the rights was 20.9 degrees; and the average for all was 22.6 degrees. In the female group the lefts averaged 25.3 degrees; the rights averaged 27.1 degrees; and the average angle for the group was 26.2 degrees. The average angle of anteversion for the entire group of thirty infant femora was 24.4 degrees.

Pairs of femora from children of known age were next studied, the ages ranging between two and fifteen years. Some of the specimens in this group were not labeled as to sex, and, because it is very difficult to differentiate the femora anatomically at an early age as to sex, this classification was not made. Of the femora of this age group (Table III),

TABLE IV

RANGE OF ANGLE OF ANTEVERSION FOR 630 FEMORA

Angle of Anteversion (*Degrees*)	Male				Female				Total Per cent.
	Left		Right		Left		Right		
	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)	(*No.*)	(*Per cent.*)	
−20 to −15.5	1	0.15	0	0	0	0	2	0.3	0.5
−15 to −10.5	2	0.3	4	0.6	4	0.6	2	0.3	1.9
−10 to −5.5	9	1.4	8	1.3	6	1.0	3	0.5	4.1
−5 to −0.5	17	2.7	17	2.7	10	1.6	8	1.3	8.3
0 to 5	35	5.6	42	6.7	24	3.8	27	4.3	20.3
5.5 to 10	57	9.0	43	6.8	37	5.9	32	5.1	26.8
10.5 to 15	34	5.4	37	5.9	22	3.5	28	4.4	19.2
15.5 to 20	17	2.7	31	4.9	10	1.6	14	2.2	11.4
20.5 to 25	8	1.3	10	1.6	5	0.8	9	1.4	5.1
25.5 to 30	3	0.5	3	0.5	2	0.3	4	0.6	1.9
30.5 to 38	1	0.15	1	0.15	1	0.15	0	0	0.5

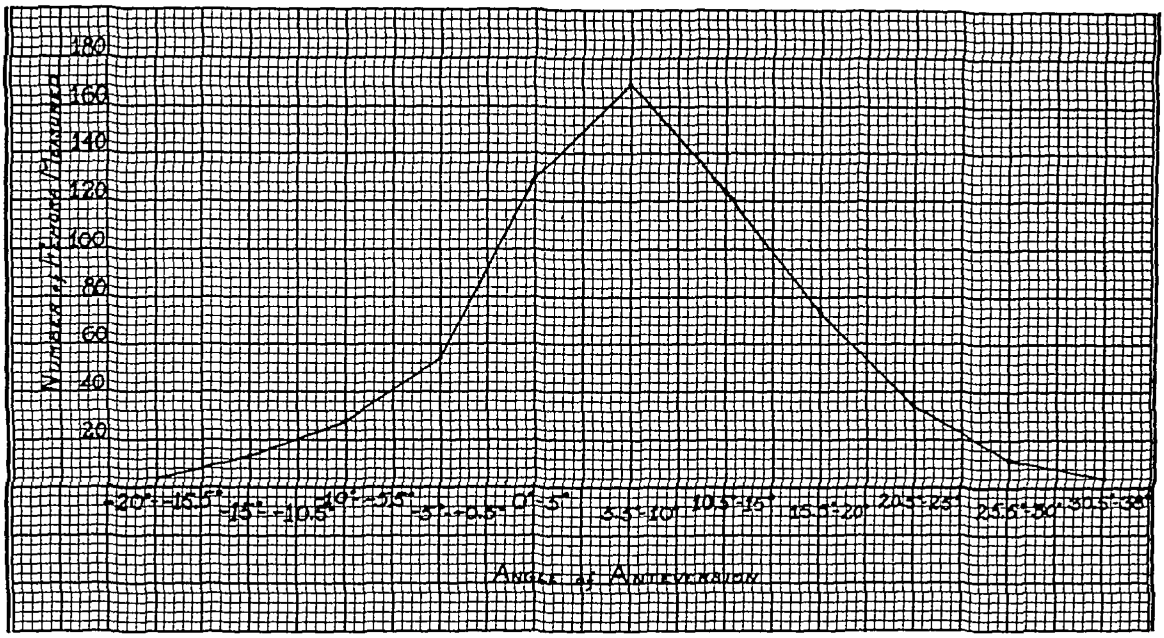

Chart I

Shows angle of anteversion and angle of retroversion.

the thirteen lefts showed an average angle of anteversion of 16.4 degrees, while the thirteen rights averaged 17.9 degrees; the total average was 17.2 degrees. This, likewise, is a small series, but it shows well that during childhood the angle of anteversion is gradually decreasing from the large angle seen at birth to the relatively small one seen in the adult.

Table IV shows the range of the angle of anteversion for the entire series of 630 adult femora measured. It shows that more than one in four have anteversion, ranging between 5.5 and 10 degrees, and that 66.3 per cent. of all those measured showed anteversion between 0 and 15 degrees. The average angle of 8.021 degrees, found in this study, is distinctly less than that observed by anyone previously. We believe that any angle greater than this is approaching an abnormal degree of anteversion, and that anything beyond 15 degrees must be considered pathological in the adult. One hundred and nineteen or 19 per cent. of the specimens studied fall in this group.

In this study many femora were found to have a reverse angle or an angle of retroversion. Most other observers have also noted this fact, but previously it has been considered an unusual finding, whereas in our study this has been a rather frequent finding. Of the entire group of adult femora measured, ninety-three or 14.8 per cent. showed this angle to be reversed, and it varied between minus 0.5 and minus 20 degrees. We see, therefore, that the reverse angle was a finding almost as common as the increase in anteversion which we considered definitely pathological (Chart I).

Finally, it was felt that by studying known pairs of femora, interesting data in this study would be obtained. The paired femora from forty-five adult anatomical specimens were obtained, and in them this angle was measured. This group was also classified as to sex, there being femora from twenty-eight males and seventeen females. In the male group the right femur had a greater angle of anteversion than the left in seventeen of the twenty-eight pairs, while in the female group it was greater in twelve of the seventeen pairs studied. Thus in the series of known adult pairs, the right femur showed an angle of anteversion greater than that seen in the left in twenty-nine of the forty-five pairs studied,—a ratio of two to one.

This has been purely an anatomical study and no attempt has been made to correlate the findings with any clinical aspects, such as those which might be applied in the study of congenital dislocations of the hip or in the treatment of fractures of the femoral neck by internal fixation.

SUMMARY

The authors feel that, in the past, the angle of anteversion of the neck of the femur has been considered to be greater than it normally is. This study has shown that 25 per cent. of all adult femora will normally have anteversion of between 5 and 10 degrees, and that 66 per cent. will fall between 0 and 15 degrees. The authors believe that any angle of anteversion in the adult femur that is greater than 10 degrees is approaching the abnormal, and that anything over 15 degrees is definitely pathological.

There are many differences between the male and female types of femur. Although the difference in the angle of anteversion is small, it should be considered as one of the characteristics of each type, - the female type showing a slightly greater amount of anteversion than the male type.

This study bears out the facts that the infant femur has a high degree of anteversion normally (this averaged 24.4 degrees); and that, during childhood and adolescence, it gradually recedes to that seen in the adult.

A reverse angle or angle of retroversion is a rather frequent finding, and its occurrence in the adult is nearly as common as the finding of an abnormal amount of anteversion.

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RECONSTRUCTION OF THE ELBOW JOINT

BY EDWARD PARNALL, M.D., ALBUQUERQUE, NEW MEXICO

If a stiff elbow can be converted into one which has a certain amount of *practical* painless motion and a reasonable degree of stability, much will be accomplished. It has long seemed to the writer that an attempt at physiological function, based on a fair knowledge of the direction healing tissues take, should be the basis for action [7, 10], rather than anatomical reproduction of the elbow joint [8]. While the approach to the joint shown in this paper was devised independently in 1939 by the writer, it is not a new one, having been used by Gutiérrez in 1925, by Milch, and by Campbell. Busto deals quite exhaustively with the subject in an interesting historical sketch. Most of the other approaches appear not to be physiological. The very easy posterior horseshoe incision strips too much periosteum and necessitates a long healing time for a transversely divided large tendon; the

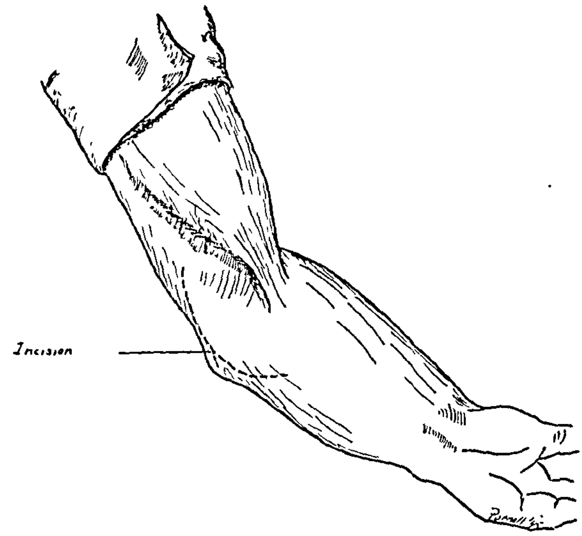

FIG. 1

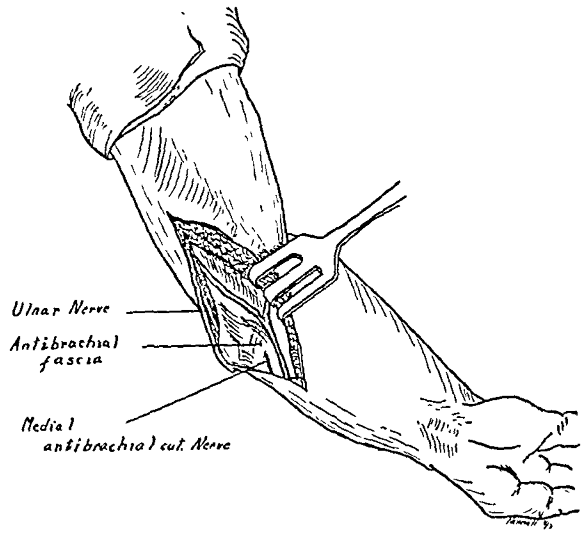

FIG. 2

Fig. 1: Dotted line shows incision. Note that it is perpendicular to skin cleavage lines at only one point.
Fig. 2: The ulnar nerve is exposed and ready for freeing.

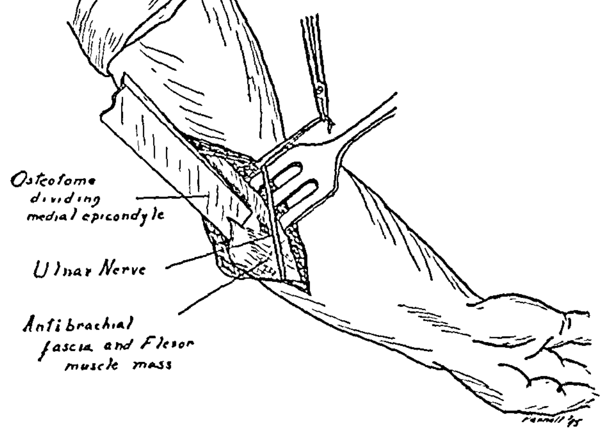

FIG. 3

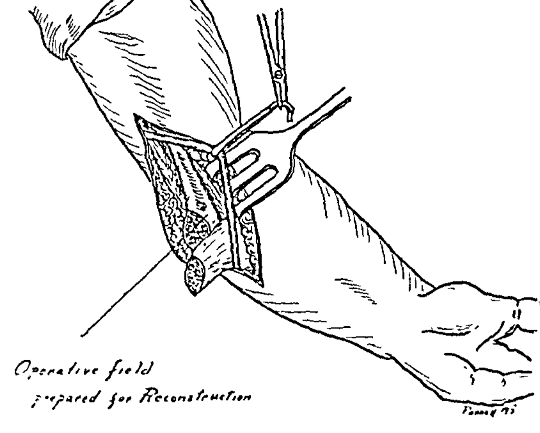

FIG. 4

Fig. 3: The ulnar nerve is retracted and the medial epicondyle is being detached with flexor muscle mass.
Fig. 4: The flexor muscle mass is reflected and the field is ready for the operation of choice.

lateral longitudinal incision is too far from its target and endangers the radial and ulnar nerves[1, 9]; and the posterior longitudinal incision[2, 5, 11], cutting across skin cleavage lines and traversing an extensor surface of a joint, merely invites keloid formation and contracture.

A consideration of the various types of substances suitable for interposition between the joint surfaces is not of great importance, as far as the elbow is concerned, since a properly conceived physiological procedure should minimize the need for an interposing substance. Several writers, notably Stamm, state that fascia lata is never necessary.

OPERATIVE PROCEDURE

A semicircular incision, five inches (thirteen centimeters) in length, is made on the medial aspect of the elbow, with its apex just anterior to the medial epicondyle of the humerus (Fig. 1). The medial antibrachial cutaneous nerve should be identified and avoided (Fig. 2).

The ulnar nerve is exposed in the upper portion of the area, dissected free in its entire course as far as its disappearance in the forearm flexors, and retracted with a tape (Fig. 3).

The medial epicondyle is cleanly divided from its parent bone, well at its base, with an osteotome (Fig. 3). The flexor muscle mass is separated by blunt dissection and retracted downward with the attached epicondyle (Fig. 4).

The soft tissues on all sides of the lower portion of the humerus and the humero-ulnar ligaments are separated by sharp dissection. The area is now exposed, and is ready for whatever reconstructive procedure good judgment dictates, from simple removal of obstructing spurs to complete arthroplasty (Fig. 5).

In closure, the detached medial epicondyle is usually dissected free and discarded. The flexor muscle mass is approximated to the remnant of the medial intermuscular septum and lightly sutured. The ulnar nerve is transposed anteriorly and subcutaneously. The wound is closed.

If necessary, a hanging cast is applied for the sake of stability and downward traction. Otherwise, a bulky dressing is used.

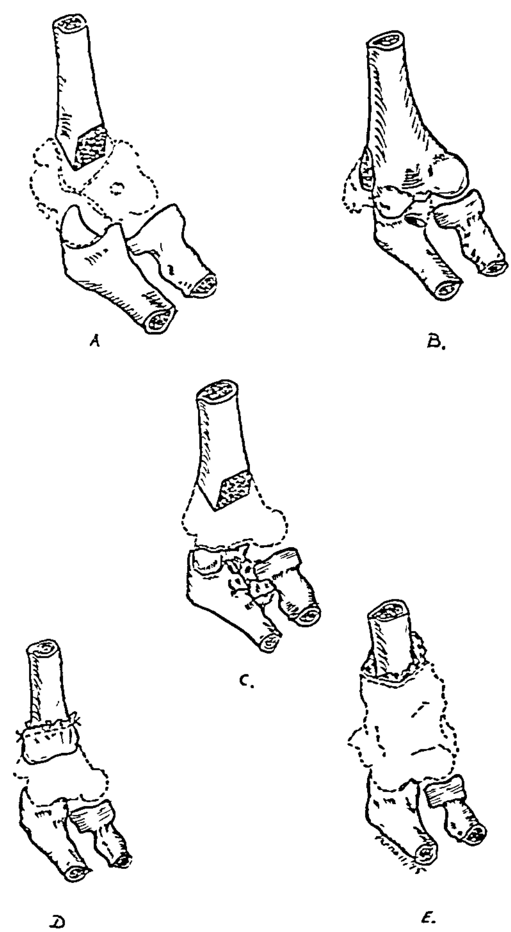

FIG. 5
Procedures followed in five cases. *A*, Case 1; *B*, Case 5; *C*, Case 4; *D*, Case 2; *E*, Case 3.

On the day after operation, the patient is encouraged to tense the triceps and biceps simultaneously in order to "snug" the new elbow joint. The cast is not retained longer than one week; at the end of this time, active graded exercises are begun. As soon as the wound is healed and the sutures have been removed, the patient should receive daily whirlpool baths. Active exercises are gradually increased until, at the end of about three weeks, the patient is working against resistance and is increasing the range of motion.

Seven elbows were repaired, all in soldiers between the ages of twenty-five and thirty-five. The elbows were approached through the medial curved incision. All of the patients except one (Case 7) had sustained missile wounds of the elbow. In Case 7 a simple fracture of the lower end of the humerus had been sustained, complicated by suppurative arthritis of the elbow. This was treated with skeletal traction.

In Case 1 the humerus was trimmed to a knife-edge, as shown in Figure 5,*A*, with no fascial covering; this is very similar to a case cited by Buckley.

In Case 2 the humerus was resected just above the trochlea and capitellum, and was covered with fascia (Fig. 5,*D*).

In Case 3 (Figs. 6-A, 6-B, 6-C, and 6-D), the patient had an ununited fracture of the humerus, with pseudarthrosis and a good deal of exuberant callus, too close to the elbow

Fig 6-A

Fig 6-C

Fig 6-B

Fig. 6-D

Figs 6-A and 6-B: Case 3. Roentgenograms taken before operation (Fig. 6-A) and six weeks after operation (Fig 6-B)

Figs 6-C and 6-D: Photographs taken six weeks after operation

TABLE I

RESULTS AFTER OPERATION

Case No.	Period after Operation (Weeks)	Motion		Joint Stability
		Full Extension Minus:	Flexion to Right Angle Plus:	
1	16	30 degrees	25 degrees	Stable
2	11	25 degrees	20 degrees	Stable
3	6	20 degrees	5 degrees	Unstable
4	10	50 degrees	30 degrees	Stable
5	12	15 degrees	5 degrees	Stable
6	16	45 degrees	15 degrees	Stable
7	12	25 degrees	25 degrees	Stable

for good bone-grafting. Although it was felt that resection of the lower fragment would cause instability, this procedure was carried out (Fig. 5,*E*), the upper fragment simply being left with its own covering of fibrous tissue.

In Case 4 there was extensive comminution and destruction of the proximal portion of the ulna. At operation, therefore, the trochlea was left to fill the remainder of the semilunar notch of the ulna, and was cut flat across, so as to teeter in seesaw fashion on the knife-edge cut from the humerus, which was covered with fascia (Fig. 5,*C*).

In Case 5 there was excessive bone proliferation in both humerus and ulna. Removal of the medial epicondyle increased motion by about 30 degrees; this was increased 25 degrees more by removal of a spur on the coronoid process. The medial epicondyle was, therefore, discarded (Fig. 5,*B*).

Case 6 was dealt with in the same way as Case 1 (Fig. 5,*A*).

In Case 7 (with ankylosis resulting from suppurative arthritis), treatment was the same as in Case 2 (Fig. 5,*D*).

The postoperative results are shown in Table I.

FOLLOW-UP STUDY

In all seven cases the patients were followed by letter. Each patient was asked to draw an angle, representing the amount of motion he had at the time (six months to a year after operation). In each case the diagram indicated that motion was nearly identical with that given in Table I. Each patient was asked specifically if he preferred the elbow he had to a stiff and painless joint; each replied in the affirmative. One patient (Case 3) stated that he could stabilize his elbow by "setting" it by muscle action, and that he preferred it to a stiff elbow.

In March 1948, a second follow-up letter was sent to each patient. Replies were received in Cases 1, 2, 3, 4, and 5. Four patients (Cases 1, 2, 4, and 5) reported exactly the same motion and expressed the same preference for a mobile elbow. In Case 3, the least satisfactory from the very beginning, the patient stated that the elbow tended to lock in extension, due to overlap of the ulna anterior to the humerus, and that he had a hard time getting his hand to his mouth. While he still expressed preference for a mobile elbow, probably some attempt should have been made to secure union of the fractured humerus, and appropriate treatment continued thereafter.

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DISCUSSION

Coxa Plana

(*Continued from page 620*)

Within the last two years, I have operated upon two patients with Legg-Calvé-Perthes disease; one wa twenty-one years old, the other forty-two. Both were disabled by traumatic arthritis, resulting from mechanically faulty hip joint. An arthroplasty was performed in each case.

The most important point to keep in mind in the treatment of Legg-Calvé-Perthes disease is that even minor deformity will bring about increasing changes and eventually will result in a disabling conditior demanding operative treatment.

Dr. M. B. Howorth (closing): Dr. Gill's statement about coxa plana and congenital dislocation of th hip is certainly well taken. The conditions are not quite the same. I might simply say this: When we pu these hips in plaster under tension, coxa plana resulted in 25 per cent. When we stopped putting them i plaster under tension, coxa plana occurred in less than 5 per cent. You might try that in congenital dislocation of the hip. I have not used the terms "aseptic necrosis" and "fragmentation". I do not think these term are proper, any more than they are for the development of callus in the healing of fractures.

I would like to add one point about the pathological changes. In the early stages, when we open the joint the cartilaginous surface of the head is round; it is not flat. The flattening in the ossified portion of the epiphysis is seen early only in the roentgenograms.

Dr. Gill's and Dr. Smith-Petersen's point about the follow-up in these cases is well taken. Probably none of us will live long enough to find the answer. The evaluation of the cases is difficult. We have had 100 cases, fifty treated by rest in bed and fifty by operation. It is not possible in twenty minutes to give the detailed results. No two cases are alike. I do not know what the final answer will be. I have found that drilling produced less residual deformity and that the hip healed more rapidly. I do not think the answer to the question is whether rest or drilling, muscle flaps or bone pegs, constitute the best treatment; rather we should find out what causes the disease, and how to prevent it. At the moment we do not know. That is where the work should be done. The only thing I know that might prevent deformity is that, as soon as symptoms develop in the hip of a child, he should be given complete freedom from weight-bearing until all spasm and limitation of motion have subsided. We have sometimes prevented coxa plana by so doing. Perhaps some of the younger group will discover the cause and the ultimate prevention of the disease.

SURGICAL TREATMENT OF INTRACTABLE PLANTAR WARTS *

BY JAMES A. DICKSON, M.D., CLEVELAND, OHIO

From the Cleveland Clinic, Cleveland

At first glance, the subject of plantar warts may seem to be too trivial for discussion, since these lesions are generally regarded as presenting a minor medical problem. It is true that 90 per cent. of them are superficial lesions, which respond readily to conservative treatment with roentgen irradiation, escharotic solutions, or electrodesiccation. However, it has not been generally or sufficiently appreciated that, in the 10 per cent. of cases of verruca plantaris which do not respond to conservative therapy, the problem is far from trivial.

Patients with these intractable lesions suffer extreme pain and serious disability, and they lose much working time and incur great expense in an effort to find relief. The typical history is that they have suffered for many years and have consulted many physicians, including general practitioners, roentgenologists, surgeons, orthopaedic surgeons, and dermatologists (and most of the patients have also seen chiropractors, chiropodists, and electrotherapists), but they still have the plantar warts, which recur or persist as ulcers on the soles of the feet. These stubbornly refuse to heal, and cause excruciating pain and difficulty in walking. Any ailment so serious to the patient demands serious consideration by the medical profession, and radical treatment, if this is necessary, to relieve the suffering.

In formulating a rationale for treatment, it is necessary to consider the pathological condition involved. An ulcerated plantar wart of long duration invariably extends through the deep fascia, sometimes down to the tendon sheaths (Figs. 1-A and 1-B), usually with ulceration and pronounced sclerosis of the surrounding tissue. Thus these lesions are not merely warts, but also deep ulcerative processes, resulting to some extent from previous treatment. Additional local application of escharotics or radiation treatment in this type of lesion is useless; the only thing that will relieve the patient is complete removal of the diseased area.

The therapeutic problem is made more difficult by the fact that all patients with these intractable warts exhibit mechanical defects in the feet, with weight thrown ab-

FIG. 1-A

FIG. 1-B

Fig. 1-A: Cross section of a gross specimen including a plantar wart, showing depth of the lesion.
Fig. 1-B: Photomicrograph (× 4) of a plantar wart, showing spurlike process extending through the subcutaneous tissue, practically to the tendon sheath, with pronounced sclerosis of adjoining tissue.

* Read at the Annual Meeting of The American Orthopaedic Association, Hot Springs, Virginia, June 28, 1947.

FIG. 2-A FIG. 2-B

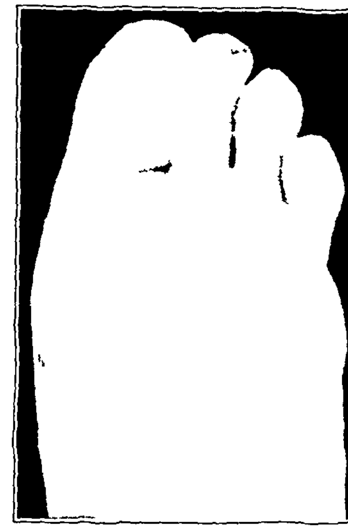

FIG. 3

Technique of operation.

Fig. 2-A: Dissection of toe and metatarsal bone.

Fig. 2-B: Operative site after removal of the metatarsal bone.

Fig. 3: Appearance two months after removal of fifth toe and metatarsal bone from left foot of a man, aged sixty-two. Two courses of contact roentgenotherapy and other local treatment had failed to give relief.

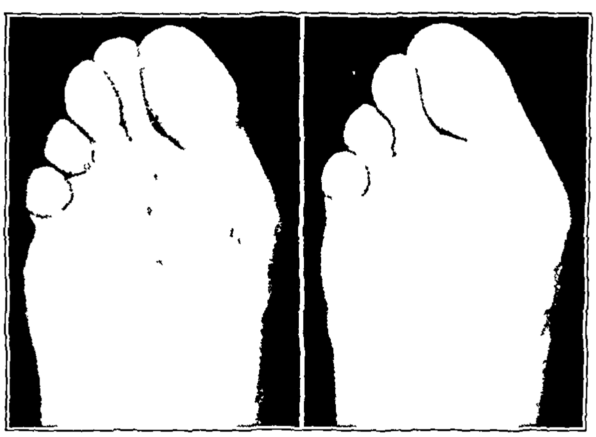

FIG. 4-A FIG. 4-B

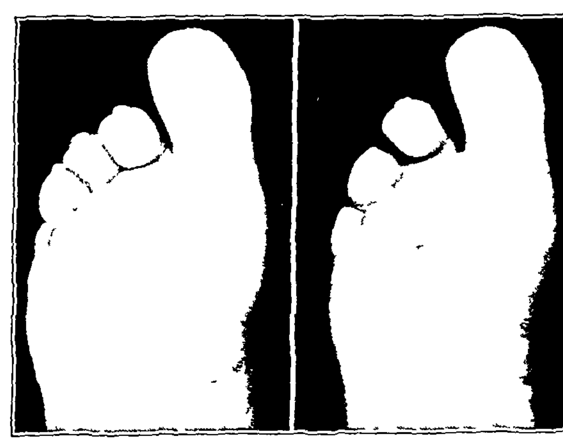

FIG. 5-A FIG. 5-B

Fig. 4-A: Ulcerated wart at the bases of the second and third metatarsal heads on the right foot of a woman, aged twenty-six. The lesion had persisted for six years, despite eight surgical removals and x-ray and radium treatments.

Fig. 4-B: Appearance of foot, two months after removal of the second toe and second metatarsal bone.

Fig. 5-A: Ulcerated wart underneath third metatarsal head, after five series of roentgen treatments administered over a four-year period, in a man, aged sixty.

Fig. 5-B: Appearance of foot, two months after removal of third toe and metatarsal bone.

normally on one of the metatarsal heads, producing a painful pressure point. Everyone who has tried to deal with these cases by surgical excision has had the great disappointment of having the wart recur, or at least of having a recurrence of painful callus, despite all attempts to relieve pressure locally by means of arch supports and other measures. Thus, even in cases which are most favorable from a surgical standpoint—that is, those in which the wart can be excised easily and satisfactory closure procured—the results usually are far from successful.

The problem becomes more difficult in those cases in which the lesion is so extensive that, when it has been completely removed, satisfactory closure is impossible without resorting to skin-grafting. Skin-grafting and plastic operations used for this type of plantar wart have been described by Ghormley and Lipscomb, Haggart, and Blair and his co-workers. Although skin-grafting has proved fairly effective in some instances, it involves a long period of hospitalization and is associated with all the uncertainties and failures

attending this type of operation. Even when skin from another area is transferred successfully, it retains the characteristics of the donor site, and may be too thin to furnish sufficient protection to the weight-bearing area of the foot. Furthermore, the difficulties of overcoming the persistent pressure point of the foot still remain, so that, even after successful skin-grafting, there may be a recurrence of the difficulty.

After many disappointments, associated with various types of treatment along these traditional lines, it occurred to the author that removal of a V-shaped section of the foot, including a wide excision of the wart, with the corresponding toe and metatarsal bone, might remove the principal causes of the difficulty and afford the desired relief to the patient. This would entirely remove the pressure point which might cause a recurrence, and would allow satisfactory closure, even when the lesion involved a very extensive area. Any necessity for skin-grafting would be avoided, and primary union would be procured, which would greatly minimize the time of hospitalization.

The first operation was performed on a woman who begged that her foot be amputated, so that she might walk without constant pain. In comparison with the treatment requested, the surgical procedure of removal of a toe and metatarsal bone was conservative, and the result was most successful.

The operation itself is not difficult. It consists in the removal of a wedge-shaped area of the foot, including the warty lesion, the toe, and the metatarsal bone which is causing abnormal pressure on the sole of the foot (Figs. 2-A and 2-B). A wide elliptical incision is made around the plantar lesion, extending between the webs on both sides of the toe to be removed, and over the dorsum. The metatarsal is exposed subperiosteally, with reflection of the intrinsic muscles. The extensor and flexor tendons are cut, and the metatarsal bone is removed near its base by bone-cutting forceps. The adjoining metatarsals are sutured together with chromic catgut through the capsule of the metatarsal-phalangeal joints, thus obliterating the space made by the removal of the bone. Skin closure is then accomplished readily.

The postoperative care consists in wearing a few layers of elastic bandage about the fore part of the foot for three or four weeks. Crutches are used when walking, to protect the foot until the wound is well healed.

The most frequent site of intractable plantar warts is underneath the head of the second metatarsal bone. Case 1 (Figs. 4-A and 4-B) had a typical history, and the illustrations show a typical result after removal of this bone. Cases 2 and 3 (Figs. 5-A, 5-B, 6-A, and 6-B) illustrate the results of operations performed on the third and fourth metatarsal areas. Case 4 (Fig. 3) illustrates the result of an operation with removal of the fifth toe, and Case 5 (Figs. 7-A and 7-B) that for a wart underneath the great toe. When the wart is

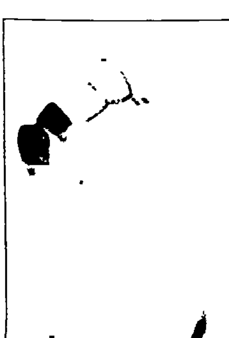

Fig. 6-A

Fig. 6-B

Fig. 7-A

Fig. 7-B

Fig. 6-A: Ulcerated wart under fourth metatarsal head of right foot in a woman, aged fifty-six. Several series of roentgen-ray treatments and cauterizations had failed to eradicate the lesion.
Fig. 6-B: Appearance of foot, two months after removal of fourth toe and metatarsal bone.
Fig. 7-A: Plantar wart at base of great toe on left foot in a woman, aged fifty-nine.
Fig. 7-B: Appearance of foot after removal of warty area and sesamoid bone.

under the great toe, the pressure point is usually caused by the sesamoid bone. In these cases, removal of the sesamoid along with the warty area has proved effective, without removal of the metatarsal head.

The author has now performed this operation in a series of twenty-five cases, and the results have been uniformly successful. He believes that this operation offers the bes' chance of relieving those patients whose plantar warts extend deep into the subcutaneou: tissue and have recurred or persisted and become more painful, despite the most skillfu use of roentgen irradiation and other conservative therapy. The operation is recom mended only for that group of patients with plantar warts which have failed to respond t conservative measures. It is a radical procedure, and is to be used only in those cases ir which, because of the persistence and depth of the lesion, radical treatment is demanded

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DISCUSSION

Dr. R. Plato Schwartz, Rochester, New York: Dr. Dickson's experience is similar to that which we have had with intractable plantar warts; but I am not sure I can agree that all intractable plantar warts are due to abnormal pressure. It seems to me they are not.

The simple untreated plantar wart usually responds to the application of a 10 per cent. solution of salicylic acid in collodion. I have not seen intractable plantar warts develop in association with this conservative treatment. In my experience, the intractable plantar wart has followed treatment of simple plantar warts by roentgen ray, fulguration, local excision, et cetera. The simple plantar wart should not receive any form of treatment resulting in a plantar scar which is subjected to pressure from an overlying metatarsal head.

Conservative local excision has resulted in failure. In due time, the healed incision is associated with the accumulation of painful scar tissue. It is important, therefore, to avoid a predisposition to such scar formation, without at the same time removing the underlying bone that gives rise to constant pressure on the overlying scar.

Dr. Dickson has presented a logical operative procedure for permanent relief from pain and disability due to intractable plantar warts. The duration of pain and the disability and expense caused by these lesions would invariably minimize the significance of radical therapy which assured elimination of these major difficulties. The absence of the metatarsal head eliminates the cause for a painful scar.

I should like Dr. Dickson to tell us the duration of time preceding operation on these patients.

Dr. Dickson has made a worth-while contribution and has given evidence which should stimulate the practice of this operative procedure. I believe that patients will accept his procedure and be very grateful for their freedom from long-prevailing pain and disability.

Dr. James E. M. Thomson, Lincoln, Nebraska: The important point Dr. Dickson has made, which was amplified by Dr. Schwartz, is that, in dealing with these conditions, we are applying well-known principles. To remove a corn and have a satisfactory result, one must take out the underlying bony prominence responsible for the skin pressure. To remove metatarsal calluses, the same thing has to be done. It would seem all right to remove one toe and its metatarsal in the treatment of a single bothersome wart, but what about those patients who have multiple plantar warts? We see such cases quite often, and I would hesitate to remove the toes under such circumstances. It has been our custom to remove the bony prominence of the metatarsal at the time the painful wart area is removed. Usually one can leave enough integument to cover the defect and get a good result. I think Dr. Dickson has shown, however, that it sometimes takes a major surgical procedure to handle what appears to be a minor disability.

Dr. J. Albert Key, St. Louis, Missouri: It seems to me that most of the lesions which Dr. Dickson showed were not plantar warts. Plantar warts do not occur at weight-bearing points; in the fore part of the foot they usually occur anterior to these points. Most of the lesions shown were calluses which I would correct by operating upon the hammertoe or by removing the head of the metatarsal. I would not take off the toe and produce an incongruity between the two feet, when cure can be effected more simply. In the occasional case, it is necessary to excise the area which had been treated by roentgenotherapy.

(*Continued on page 789*)

EOSINOPHILIC GRANULOMA OF BONE

Report of Six Cases

BY JOSEPH L. PLATT, M.D., AND RICHARD B. EISENBERG, M.D., PHILADELPHIA, PENNSYLVANIA

From the Department of Orthopaedic Surgery and the Department of Surgical Pathology, Hospital of the University of Pennsylvania, Philadelphia

In 1940, Lichtenstein and Jaffe, and Otani and Ehrlich independently described cases having bone lesions which were granulomatous in nature and to which Lichtenstein and Jaffe gave the name of eosinophilic granuloma of bone. It is the purpose of this paper to report six new cases which have been observed in the Hospital of the University of Pennsylvania within the past four years.*

Five of the cases are summarized in Table I. Case 6 is presented in more detail, as it illustrates the benign nature of the lesion and the results of conservative treatment. In this case, the diagnosis of eosinophilic granuloma was suspected prior to biopsy.

CASE 6. P. H., a white male, fourteen years old, was admitted to the Hospital of the University of Pennsylvania on April 9, 1946, because of an enlargement over the right mandible and roentgenographic evidence of destructive lesions in the skull, right mandible, and right femur.

In September 1944, eighteen months before admission, the patient had begun to complain of aching pain in the right hip, occurring at night. The pain did not occur while he was walking. Roentgenograms of the hip were negative. In January 1945, repeated roentgenographic study revealed, in the neck and intertrochanteric region of the right femur, numerous small, irregular, and confluent cystic areas with some accentuation of the trabeculations in the less involved adjacent areas. There was slight cortical thickening, indicating a periosteal reaction. The changes involved the epiphysis of the greater trochanter (Fig. 5-B).

Laboratory studies were as follows:

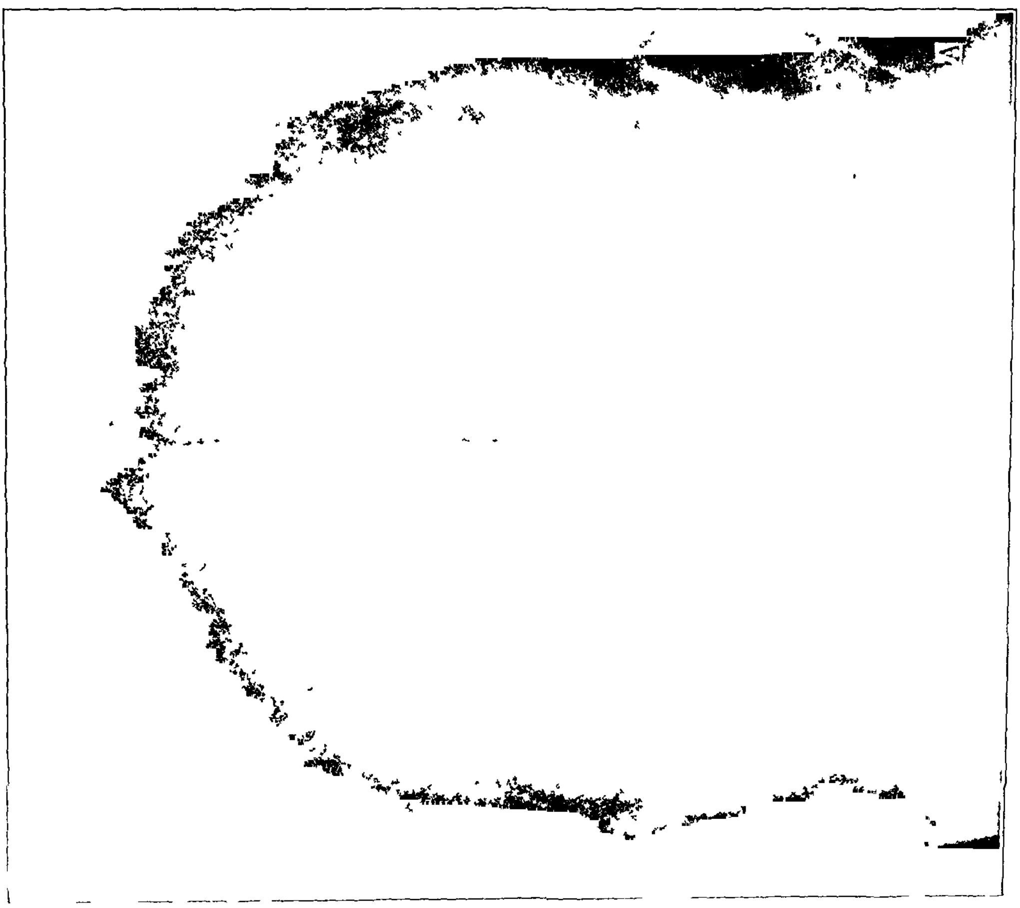
Red blood cells	5,200,000
Hemoglobin	97 per cent.
White blood cells	8,900
Polymorphonuclear neutrophils	75 per cent.
Lymphocytes	22 per cent.
Eosinophils	3 per cent.
Sedimentation rate	Markedly increased

In February 1945, the boy was seen as an ambulatory patient in the Department of Orthopaedic Surgery. Pain had not occurred during the preceding three weeks, and he had no new complaints. Examination revealed an undernourished boy with poor posture. There was slight tenderness over the greater trochanter on the right, and some limitation of hip motion. The lesion was thought to be a cyst, but the possibility of tuberculosis was also considered. Because of recent clinical improvement and since roentgenograms indicated that the hip was mechanically secure, it was decided to observe the patient.

In the first week of April 1945, a cystic lesion, tender to pressure, developed in the left frontal region of the scalp. Roentgenograms of the skull showed a large area of sclerosis, with scattered osteolytic defects, in the superior portion of the left frontal bone. The normal diploic and trabecular pattern was accentuated in the sclerotic areas and irregularly preserved in the osteolytic areas. Two months later, the mass was somewhat larger and fluctuant. It overlay a crater-like skull defect. Roentgenograms revealed a marked increase in the osteolytic reaction and an area of mottled bone destruction, four by five centimeters in size, without surrounding bone reaction. By September 1945, the mass had disappeared and no skull defect could be palpated. In November 1945, another mass appeared in the scalp and ran much the same course as the first lesion. Figure 5-A shows the roentgenographic appearance of the skull lesion in January 1946. Roentgenograms of the right femur at this time showed less bone destruction, with considerable filling in of the cystic areas.

During the time of observation, from February 1945 until March 1946, the patient had no complaints and attended school regularly. He maintained his weight.

* Cases 1, 2, and 3 were treated in the Department of Neurosurgery, and are reported by permission of Francis C. Grant, M.D. Cases 4, 5, and 6 were treated in the Department of Orthopaedic Surgery, and are reported by permission of Paul C. Colonna, M.D. Histopathological studies were made in the Department of Surgical Pathology, under the direction of Robert C. Horn, M.D.



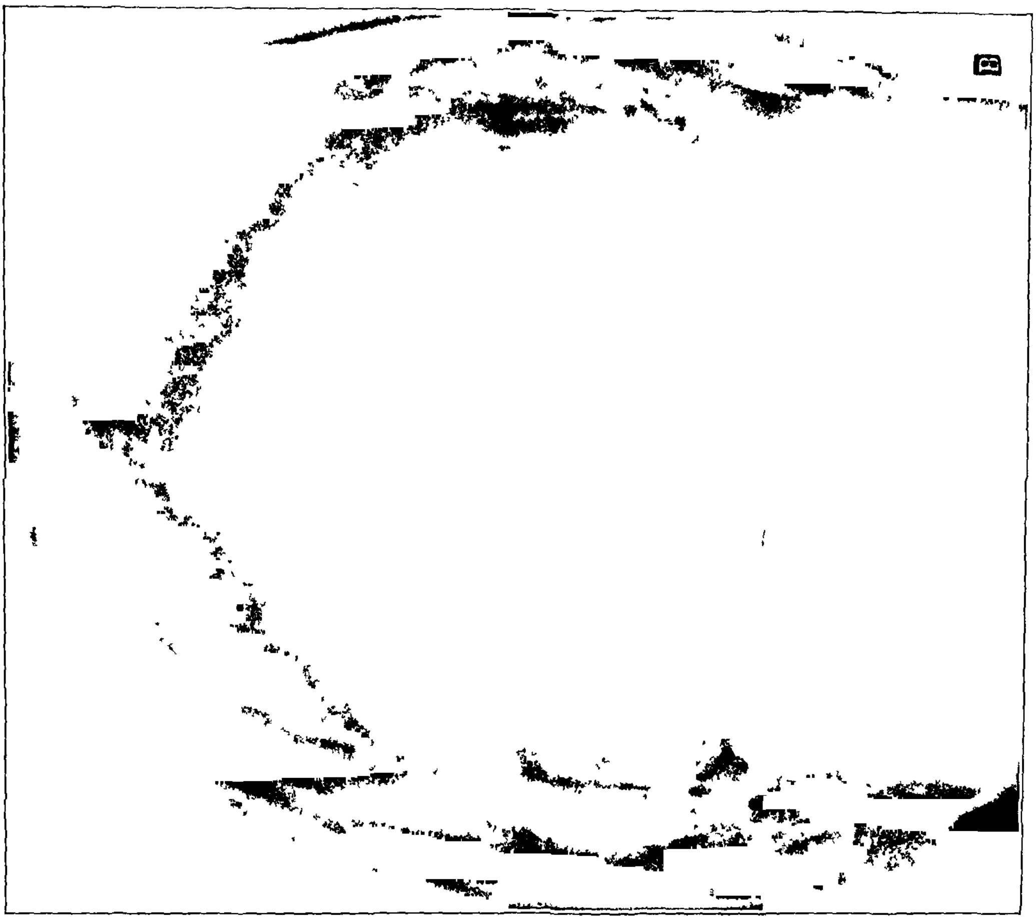


FIG. 1

Case 1. *A*: Roentgenogram of skull shows an extensive, irregular, osteolytic defect in the right occipital area, involving the foramen magnum. The process covers an area measuring six by six centimeters on the film. Both tables are irregularly involved. This roentgenogram was made three and one-half months after biopsy and roentgenotherapy.

B: Twenty-nine months after biopsy and roentgenotherapy, only a poorly defined osteolytic defect, five millimeters in diameter, remains in the occipital bone.

TABLE I
SUMMARY OF CASE REPORTS

Case	Admitted to Hospital (*Date*)	Symptoms and Duration	Physical Findings	X-ray Findings	Treatment	Length of Follow-up (*Months*)	Result	Preoperative Diagnosis
1, R. J. White male, 2 years, 9 months old	Jan. 10, 1944	Stiff neck with pain on motion, 2 months. Growth in neck, 2 weeks	Soft-tissue mass, 2–3 cm. in diameter, occipital region	Large defect, right occipital region of skull, involving foramen magnum (Fig. 1)	Local roentgenotherapy	17	Asymptomatic. X-ray, Sept. 1946, showed skull defect filled in	Sarcoma
2, L. B. 3-year-old white female	May 23, 1944	Asymptomatic growth, right posterior frontal region, 2 months	Soft cystic tumor, 3 cm. in diameter, with palpable bone defect	Bone defect, 3-4 cm. in diameter, right frontal area (Fig. 2)	Bloc excision of tumor mass, June 1944. Cranioplasty for repair, June 1946	31	Asymptomatic	Malignant tumor
3, K. L. 15-year-old white female	Nov. 22, 1944	Asymptomatic growth, left frontal area, 2 months	Small cystic tumor, left frontal area	Dime-sized area of destruction, left frontal bone	"Hulling out" of tumor mass occupying skull defect, Nov. 1944. Local roentgenotherapy, Apr. 1945	21	Asymptomatic X-ray, June 1946, showed skull defect still present No new area	Sebaceous cyst; malignant tumor
4, R. L. White male, 35 years old	Apr. 11, 1946	Persistent dull aching pain, left shoulder, 1 month	Slight enlargement and pain on pressure, distal third left clavicle	Osteolytic area with pathological fracture, left clavicle (Fig. 3)	Excision lateral third left clavicle, Apr. 1946	8	Asymptomatic, working full time as truck driver	Latent bone cyst, malignant tumor
5, F. E. 12-year-old white male	June 18, 1946	Vague pains in left hip and knee, 3 months	Slight tenderness, upper, inner aspect of left femur	Osteolytic lesion in upper left femur with "onion-skin" layers (Fig. 4)	Curettement of lesion through a window	15	Asymptomatic. X-ray, June 1947, showed healing complete	Osteomyelitis; Ewing's tumor; eosinophilic granuloma

Case 1: Biopsy (Jan. 18, 1944) showed a tumor mass filling the bone defect and bulging into muscle tissue. Blood cholesterol 142 milligrams per 100 cubic centimeters.
Case 5: Determinations of the serum calcium, organic phosphorus, and alkaline phosphatase were within normal limits. Blood cholesterol 232 milligrams per 100 cubic
centimeters. Bacteriological study, including guinea-pig inoculation with material from the lesion, was negative. This patient had an unexplained, intermittent, low-grade
fever for two and one-half years prior to discovery of the bone lesion. This persisted during his hospital stay.

Cases 2, 3, and 5 had 2 to 4 per cent. of eosinophils on blood smear. In Cases 3 and 4, differential counts were not done. The temperatures were not elevated except in Case 5.

The patient was admitted to the Hospital on April 9, 1946. During the three weeks just prior to admission, a mass developed over the angle of the right mandible. Although this had been soft at first, it had now become firm. Movement of the jaw was limited and painful.

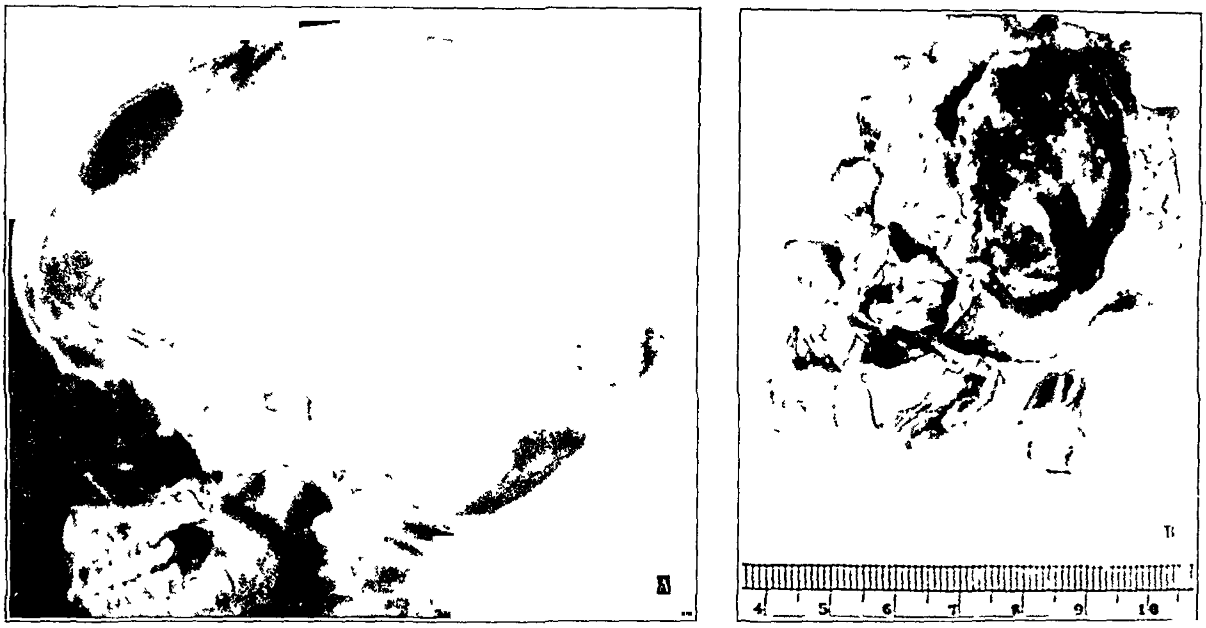


FIG. 2

Case 2. *A:* Roentgenogram (May 26, 1944) shows an osteolytic defect with slight variation in the involvement of the inner and outer tables in the right frontal bone. There is no eburnation of the margins. The defect underlies a cystic tumor mass.

B: Gross specimen shows a circle of resected skull, enclosing a soft granulomatous mass.

FIG. 3

Case 4. *A:* Roentgenogram of the left clavicle (March 29, 1946), showing a cystic defect in the lateral third with an incomplete, transverse pathological fracture. The cortex is thickened and there is callus formation at the fracture site.

B: In the gross specimen, the resected lateral third of the clavicle has been sectioned longitudinally. A soft, yellow-tan, granulomatous tissue projects from the cut surface. The specimen illustrates the destructive nature of the lesion.

The patient, although thin and pale, was active and alert and did not appear acutely ill. The rectal temperature ranged between 99.6 and 100 degrees. There was a firm, soft-tissue mass, about two inches in diameter, situated over the angle of the right mandible and extending to the temporomandibular joint. The mass was firmly fixed to the deep structures, but not adherent to the skin. It was slightly tender. The jaw could be opened one inch. Examinations of the skull and hips were negative. There were no abnormal neurological findings.

Laboratory studies were as follows:

Hemoglobin	72 per cent.
White blood cells	6,200
Polymorphonuclear neutrophils	63 per cent.
Lymphocytes	37 per cent.
Blood cholesterol	252 and 219 milligrams per 100 cubic centimeters
Serum calcium	11.4 and 10.7 milligrams per 100 cubic centimeters
Inorganic phosphorus	5.3 and 4.6 milligrams per 100 cubic centimeters
Acid phosphatase	0 3 Shinowara unit
Alkaline phosphatase	10.8 Shinowara units

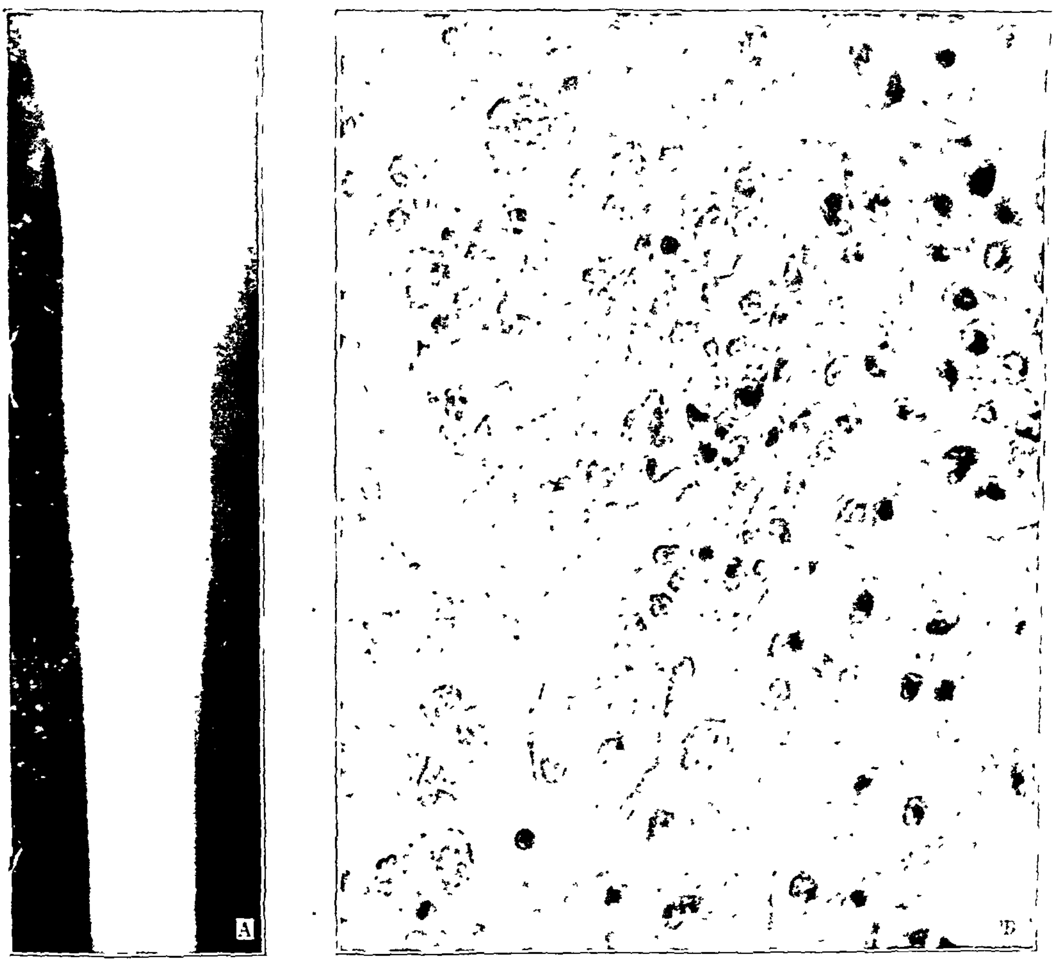


FIG. 4

Case 5. *A:* Roentgenogram of the femur (June 29, 1946) shows an osteolytic defect, measuring 1.5 by 2.5 centimeters on the film, in the proximal third of the shaft. There is irregular preservation of the surrounding trabeculation. No significant sclerosis of the bone is present, but the cortex is thickened and multiple layers of an "onionskin" type periosteal reaction are seen over a ten-centimeter zone of bone. No reactive cuff of bone is present at the margins of these layers.

B: Photomicrograph (× 540) of section made from tissue obtained by curettement. There are numerous macrophages and eosinophils. Some of the macrophages contain granules in their cytoplasm, suggesting ingestion of eosinophils.

Urinalysis, including an examination for Bence-Jones protein, was negative. A blood serological test for syphilis was negative.

Roentgenographic Studies

A bone survey showed only one new lesion. This was an irregular area of bone destruction, measuring one by two centimeters on the film, at the angle of the right mandible. The osteolytic process in the skull showed marked regression; however, a large part of the frontal bone, especially on the right, showed mottling with numerous small osteolytic areas, having a tendency to coalesce; some measured seven millimeters in diameter. There was no surrounding bone reaction. The process in the upper portion of the right femur also showed marked regression with filling in of the cystic areas in the greater trochanter, but a large area of mottled denser bone was still left in the neck and upper shaft.

Diagnosis

The clinical diagnosis was eosinophilic granuloma or Schüller-Christian disease.

Operation (performed by Dr. Colonna)

On April 18, 1946, an incision was made over the tumor mass. On splitting the right masseter muscle, a fairly large cavity, containing a poorly organized blood clot, was found. A curette was inserted, and came into contact with hard cortical bone; no definite cavitation could be found in the bone. The bone in this area was curetted and sent to the pathology laboratory. A specimen, including soft tissue, was also sent to the laboratory for bacteriological examination. This was later reported as negative for micro-organisms, including fungi.

Pathologist's Report

The intertrabecular areas not involved in fibrosis were the site of a richly cellular infiltration, composed chiefly of large mononuclear cells in which multinucleated giant cells and eosinophils were very conspicuous. The diagnosis was eosinophilic granuloma (Fig. 5-C).

Progress

The postoperative course was uneventful, the wound healing by first intention. On May 2, 1946, roentgenotherapy was begun. Treatment was given to the frontal region, right jaw, and right hip. At the time of discharge, on May 7, 1946, enlargement of the jaw had subsided and the patient was able to open his mouth fully without discomfort.

The patient was seen again on October 23, 1946. He was in good health, was gaining weight, and had no complaints. No new masses had developed. Roentgenograms showed almost complete regression of all the lesions. When he was seen in January 1947, he had gained weight and had remained asymptomatic. Follow-up roentgenograms, on November 14, 1947, showed a few small areas of decreased density in the occipital region of the skull. The patient had no symptoms. A small amount of radiation therapy (300 r) was given. The old lesions remained healed.

DISCUSSION

Laboratory studies, although not complete for every case, were not helpful in making a diagnosis. The non-specificity of laboratory studies is, in itself, of some aid in diagnosis. As can be surmised from the case reports, the actual diagnosis rests upon histopathological study.

In discussing therapeusis, it must be borne in mind that we are dealing with a condition which has a strong tendency toward healing. This is apparent, in view of the uniformly good results following a variety of therapeutic measures.

Our experience indicates that some beneficial results may be expected from roentgenotherapy. In both Case 1 and Case 6, roentgenotherapy was followed by marked improvement. In Case 6, although spontaneous regression had been noted in lesions of the femur and skull, a new lesion appeared in the mandible, seventeen months after the onset of the initial symptoms. Symptoms resulting from this latter lesion rapidly disappeared after biopsy and irradiation. Whether the rapid clinical improvement was due to the biopsy, to irradiation, to a combination of the two, or whether it was coincidental, cannot be ascertained. Solomon and Schwartz have reported rapid clinical improvement following biopsy without irradiation. In Case 5, healing occurred after curettement.

Roentgenotherapy was administered in Case 1 and Case 6 with factors of 200 kilo-

Fig. 5-A

Fig. 5-B

Fig. 5-A: Case 6. Roentgenogram of skull (January 5, 1946) shows several large osteolytic defects, involving both inner and outer tables, and numerous smaller defects, with tendency to confluence. No sclerosis is present.

Fig. 5-B: Roentgenogram of upper portion of femur (January 29, 1945), showing mottled bone destruction in the neck and upper shaft, with extension across the epiphyseal plate of the greater trochanter and cystic lesions in the trochanter. There is local sclerosis of bone and accentuation of the normal trabeculation.

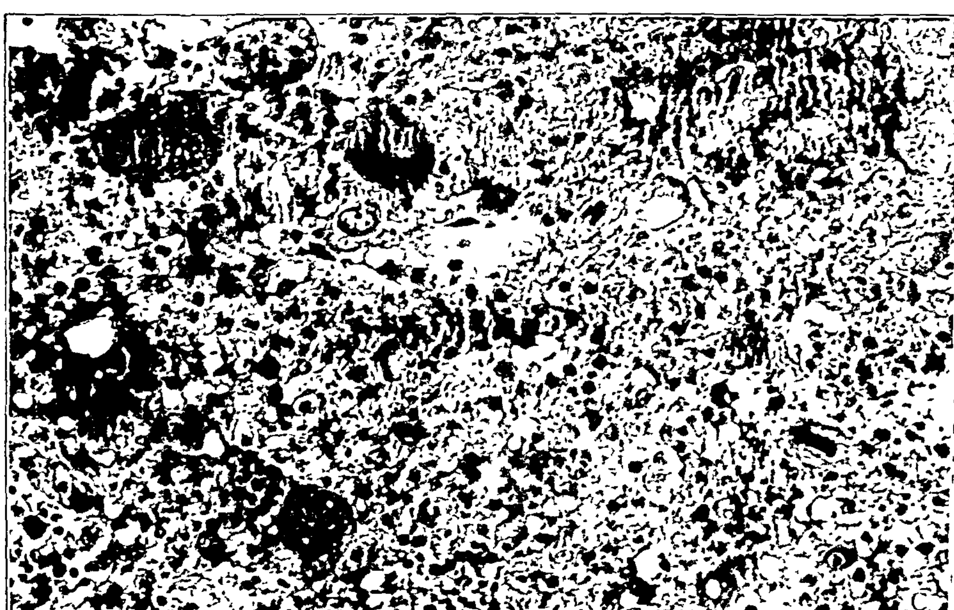


Fig. 5-C

Photomicrograph (× 300) of mandibular lesion from the same case. Numerous large mononuclear cells, together with large numbers of eosinophils, make up the bulk of the tissue. Multinucleated giant cells are a conspicuous feature.

volts, 15 milliamperes, 0.5 millimeter copper and 1 millimeter aluminum filtration, a half-value layer of 1 millimeter of copper, and a 50 centimeter distance, a 9 or 12 centimeter

circular portal being used. These patients received doses of 100 to 200 roentgens daily or on alternate days, for a total of 1,500 r in Case 1; in Case 6, 900 r were given to the right jaw, 800 r to the right frontoparietal area, and 800 r to the upper portion of the right femur. The other patient, Case 3, was treated with factors of 135 kilovolts, 8 milliamperes, 0.25 millimeter copper and 1 millimeter aluminum filtration, a half-value layer of 9 millimeters of aluminum, and a 25 centimeter distance, a 20 centimeter circular portal being used. Doses of 50 r were administered daily until a total of 300 r had been given. These doses are those measured in air roentgens at the end of the treatment cone. No patient showed any ill effects from the treatment. In Case 1, local loss of hair took place for a few months. With the exception of the study by Hamilton and his associates, reports indicate that roentgenotherapy is followed by bone regeneration (see Case 1 in this series). The most effective dose and the rate of administration have not been determined. However, healing may also take place in the absence of any definitive treatment.

Wide surgical excision, as was carried out in Case 2, does not seem justified. Our experiences at the Hospital of the University of Pennsylvania, together with the information gained from an analysis of the reported cases, suggests that surgery in suspected cases of eosinophilic granuloma of bone might well be limited to that necessary to secure an adequate biopsy or to relieve local pressure in skull lesions, and that, after the diagnosis has been established, this should be followed by radiation treatment of all lesions.

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EXPERIMENTAL DEGENERATION OF THE SUPRASPINATUS TENDON *

BY CHARLES LAIRD WILSON, M.D., C.M., F.R.C.S. (C.) †, ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University School of Medicine, St. Louis

The pathology of rupture and degeneration of the supraspinatus tendon in humans has been described in a previous publication[9]. It has been shown that a characteristic type of degeneration precedes and leads to rupture of the tendon. There has been much speculation concerning the cause of this syndrome. Many surgeons believe that rupture usually occurs in a tendon which has undergone degeneration and has then been subjected to trauma[1, 6, 8, 10]. To explain the degeneration, some authors[3, 4, 5] have postulated a senile change, but have gone no further. Others[1, 10] have suggested the possibility of deterioration of the vascular supply. The change has also been called a "sclerosization"[7]. It has been shown that characteristic, microscopic, degenerative changes make their first appearance relatively early in adult life and increase with age[9]. The purpose of this paper is to describe the experimental production of these pathological changes in the supraspinatus tendons of rabbits.

The various stages in the development of the degenerative lesion in the human supraspinatus tendon are as follows: The earliest histological evidence of degeneration, which can be observed in sections stained with hematoxylin and eosin, is a loss of the normal wavy outlines of the collagen bundles of the tendon. These become straighter and tend to merge with each other, so that individual fibers and bundles are blended, and the structure of the tendon becomes homogenous in appearance. The homogenous areas stain less deeply with eosin than do the normal portions. The nuclei of the connective-tissue cells lose their normal arrangement and configuration and become distorted. As the degeneration proceeds, the homogenous areas break up and fray, and have an oedematous, fibrillated appearance. An increase in the number of blood vessels supplying the degenerated areas is observed concurrently with this change[9].

MATERIALS AND METHODS

Both shoulders of twenty-four rabbits were operated upon with the exception of two shoulders which were used as controls. An incision 2.5 to 5 centimeters long (one to two inches) was made over the tip of the shoulder. The deltoid muscle was split, and the roof of the subdeltoid bursa was incised, exposing the supraspinatus tendon on the floor of the bursa. The tendon was then traumatized close to its insertion into the humerus. The method generally used was to cut the tendon with a scalpel point in a crisscross fashion to a depth of 1 to 1.5 millimeters. Blood was allowed to ooze into the wound, and then the cut area was crushed between the jaws of a hemostat for a few seconds. The incision was then closed in layers. Fine black silk was used throughout. At intervals varying from forty-two to one hundred and eleven days, these shoulders were re-opened through the previous scars, and the bursae were explored. Sections of the supraspinatus tendon were taken for microscopic study. These comprised the full thickness of the supraspinatus tendon from its junction with the muscle to its insertion into the humerus. At this time, sections of the supraspinatus tendons were taken as controls from the two shoulders which had not been operated upon. All specimens were preserved in formalin and were stained for microscopic study.

OBSERVATIONS

The normal subdeltoid bursa in rabbits was found to be lined with a smooth, glistening synovial membrane. Its diameter was usually 1 to 1.5 centimeters. As in humans,

* This study was aided by a grant from the National Foundation for Infantile Paralysis, Inc.
† Fellow in the Medical Sciences of the National Research Council.

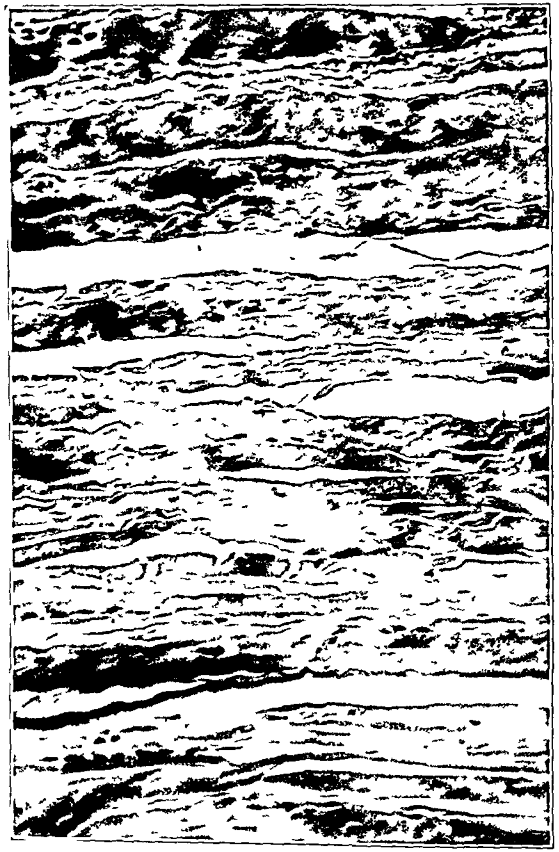

FIG. 1

FIG. 2

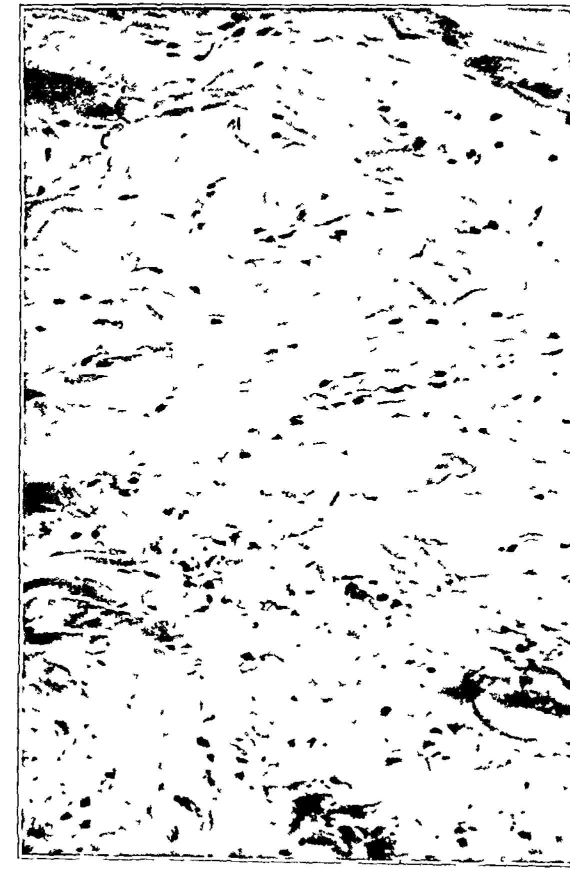

FIG. 3

Fig. 1: The collagen bundles are discrete and have a wavy appearance. The fibroblasts lie between the individual collagen bundles with the long axes of their nuclei parallel to the bundles. There are few blood vessels (× 100).

Fig. 2: The collagen bundles are less discrete and have lost their normal wavy outline. The nuclei are rounded and their polarity is becoming less definite (× 100).

Fig. 3: The normal structure of the tendon is becoming lost. Strands of collagen bundles appear to be melting away into a loose oedematous-appearing tissue. The nuclei of the fibroblasts are pyknotic and lie with no apparent polarity. This is thought to be an early stage of the marked fibrillation seen in ruptured human tendons (× 100).

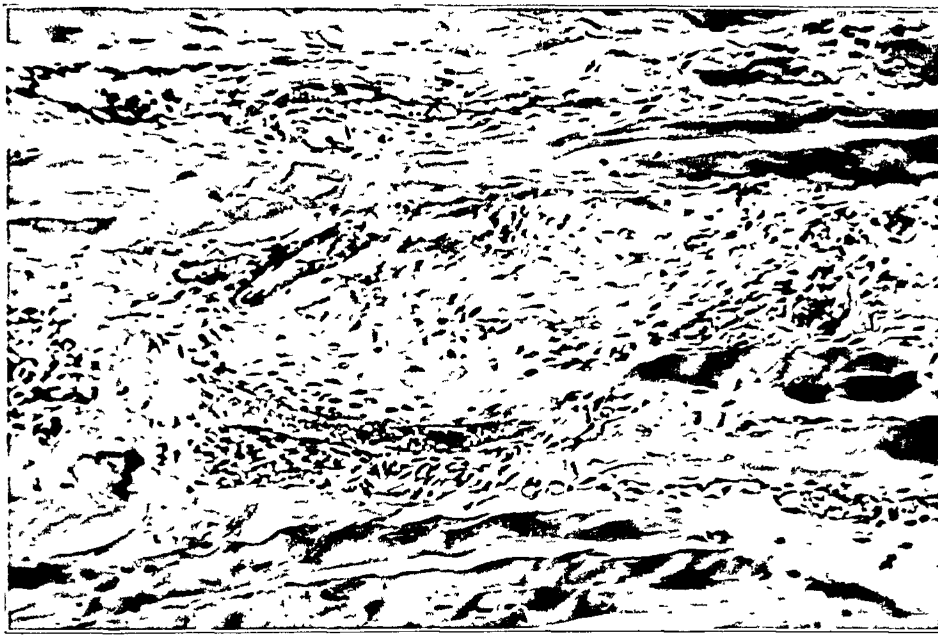

Fig. 4
There is a great increase in the vascularity of the tendon. Surrounding this area are signs of degeneration (× 120).

the short rotator cuff showed no line of demarcation between the tendons, which were blended into a smooth sheet of tendon tissue as they approached their insertion into the humerus. There were no gross or microscopic differences observed between the structure of human and rabbit tendons.

All wounds healed by primary intention. Of the forty-six shoulders which were reopened, there was complete obliteration of the bursa by scar tissue in five. Seventeen bursae were not obliterated but showed dense adhesions; nineteen showed fine adhesions; and five were normal to gross examination. No instances of rupture of the supraspinatus tendon were observed.

Microscopic Observations

In the normal, control tendons (Fig. 1) the microscopic appearance was the same as observed in normal human tendons. The collagen bundles were discrete and had a wavy appearance. The fibroblasts were lying between the individual collagen bundles with the long axes of their nuclei parallel to the bundles. The number of blood vessels was minimal.

In the experimental tendons, various degrees of degeneration were noted. The first change observed was a loss of the normal wavy outlines of the collagen bundles, which soon assumed a homogenous appearance. The nuclei of the fibroblasts became slightly more oval, and were deranged so that their long axes were not so noticeably parallel to the collagen bundles (Fig. 2). The next change observed was a more complete loss of the normal tendon structure. This consisted in a disappearance of the discrete collagen bundles and the formation of a loose oedematous-appearing tissue in which a few loose strands of the collagen bundles could be seen. The nuclei of the fibroblasts were shrunken and pyknotic, and lay with no apparent polarity (Fig. 3). This change has been termed "early fibrillation". Nowhere was there observed the marked fibrillation seen in ruptured human tendons. Along with these changes, there was an increase in the number of blood vessels in the tendon structure (Fig. 4).

Of the forty-six traumatized tendons, forty (87 per cent.) showed a homogenous

appearance with loss of the normal collagen waves, eighteen (39 per cent.) showed early fibrillation of the tendon structure, and twenty-two (48 per cent.) showed an increase in the number of blood vessels in the tendon. In all instances, the degenerated portions of the tendon stained a lighter pink with eosin than the normal areas.

These areas of degeneration did not necessarily involve the whole tendon. Normal-appearing tendon structures could often be seen bordering the degenerated areas. This corresponds to the observations made in human tendons, where normal tendon structures have been found in ruptured tendons.

There were no definite calcium deposits observed, but in three sections there were areas which stained a deep blue with hematoxylin, suggesting the beginning of calcium deposition in the tendon.

COMMENT

It has been demonstrated [9] that, in the case of the human shoulder joint, increasing age and mechanical use are important factors in causing the degeneration of the supraspinatus tendon which leads to rupture. Both the degenerative changes in the tendon and the incidence of rupture increase with advancing years, and both occur with unexpected frequency in persons who have done heavy manual labor. There has been much speculation upon the cause of the changes in the tendon. They have been attributed to mechanical compression, attrition, ischaemia, and old age. It is evident that trauma enters into all of these supposed etiological factors.

This study demonstrates that a single trauma can produce a type of degeneration indistinguishable microscopically from the degeneration which is observed in a human supraspinatus tendon which has undergone either partial or complete rupture. There is the same loss of the wavy configuration of the collagen bundles, the same homogenous appearance, the same pale-pink staining of the damaged areas with eosin, and the same increase in the number of blood vessels found in the degenerated tendon. In the rabbit sections, there was early fibrillation, but not the marked fibrillation seen in the human tendons. There is no reason to suppose that this difference is other than one of degree. Perhaps more time or repeated traumata are required to produce this further change. A slight but definite increase in the evidences of degeneration was observed as the time which had elapsed between the trauma and the biopsy increased. This was an average increase only, since all of the signs of degeneration could be found in some of the sections taken earlier.

The period of time during which these cases were followed was not long enough to expect any associated rupture of the supraspinatus tendon to occur, especially since the rabbits were caged most of the time,—thus discouraging any great physical activity. The changes described, however, are those associated with and believed to precede rupture of the human supraspinatus tendon. It has also been shown that human tendons which show these signs of degeneration have a diminished tensile strength, which renders them liable to rupture under a stress that would leave a normal tendon intact.

Eight of these cases were followed longer than 100 days. There was no evidence of the signs of degeneration being reversible, other than the increased blood supply. It is not suggested that, in all the human cases of tendon degeneration with subsequent rupture, a single trauma is responsible, since many tendons showing these degenerative signs have not ruptured, and since in humans the process may be reversible to a certain extent, over a long period of time. It is suggested, however, that oft-repeated traumata may make the degenerative lesions permanent and more severe. This is borne out by the increased incidence of both degeneration and rupture of the supraspinatus tendons in humans with advancing age and with heavy manual labor.

That calcification may occur following trauma to a tendon is suggested by the areas which stained a deep blue with hematoxylin.

SUMMARY AND CONCLUSIONS

1. The supraspinatus tendon was traumatized in forty-six rabbit shoulders. These tendons were examined at intervals varying from forty-two to one hundred and eleven days.

2. When the shoulders were re-opened for biopsy, only five of the subdeltoid bursae had a normal appearance; nineteen showed fine adhesions; seventeen showed dense adhesions; and five were completely obliterated.

3. Some of the evidences of tendon degeneration observed in either partially or completely ruptured human supraspinatus tendons were reproduced in the supraspinatus tendons of rabbits by a single trauma.

4. The microscopic evidence of tendon degeneration was a loss of the normal wavy configuration of the collagen bundles, the homogenous appearance of the tendon, a cha ge in the character of the staining properties, an increase in the number of blood vessels observed, and the loose, oedematous, fibrillated appearance of the degenerated tendons. This fibrillation was not so marked as that observed in human tendons which had ruptured.

5. Of the forty-six tendons, 87 per cent. showed a loss of the normal wavy configuration of the collagen bundles and, instead, had a homogenous appearance, 39 per cent. showed early fibrillation, and 48 per cent. showed an increase in the number of blood vessels supplying the tendon.

6. It is concluded that the degeneration observed in the human supraspinatus tendon is caused by trauma incurred during the life of the individual.

Acknowledgement is made to Dr. J. Albert Key for his valuable criticism and help in the preparation of this work, and also to Mr. Duane Taylor for his assistance in performing the operations and to Mr. K. Cramer Lewis for his photography.

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MYXOCHONDROSARCOMA OF THE TALUS

BY H. PAUL LONGSTRETH, M.D., PIO BLANCO, M.D., AND SAMUEL SANES, M.D.
BUFFALO, NEW YORK

From the Departments of Orthopaedic Surgery and Pathology, Edward J. Meyer Memorial Hospital and University of Buffalo Medical School, Buffalo

Primary malignant tumors of the talus are rare. Ten cases [1–5, 7–9], described in detail, have been collected from the available literature of the past fifty years. Four of these (one reported by Giuntini and three by Geschickter and Copeland), are cases of myxochondrosarcoma. The authors' purpose is to describe an additional case of myxochondrosarcoma in a man, sixty-two years old, and to summarize the published reports of primary malignant tumor of the talus.

CASE REPORT

N. G. (No. 410918), a white man, sixty-two years old, was admitted to E. J. Meyer Memorial Hospital on June 27, 1944, because of swelling and pain in the right ankle.

The history disclosed that, in May 1942, the patient tripped while at work and injured his right ankle, with resultant pain and swelling. He was told that he had incurred a sprain. Rest and soaking did not relieve the pain, which was sharp, knifelike, and throbbing; the swelling progressed. The pain was made worse by motion.

In July 1942, the patient had been admitted to another hospital. On examination, the medial side of the right ankle, in the region of the head of the talus, showed a hard mass which extended from the ankle joint forward to the talonavicular joint. Motions of the ankle joint were limited; pronation and supination were practically absent. Roentgenograms revealed a tumor on the superficial surface of the talus, extending into its neck. There was bony destruction of the superior border of the talus with invasion of the overlying soft tissue. On the basis of a biopsy examination, a diagnosis of chondrosarcoma was made. From 1942 to 1943, the patient received roentgenotherapy, a total skin dosage of 5,700 r to the right foot in two courses.

In May 1944, the skin on the right foot and on the lower part of the right leg was found to be pigmented. The dorsum of the foot presented a fluctuant mass. Roentgenograms showed no essential change in the bone. The patient complained of pain in the ankle, but he refused operation.

On admission to this Hospital, in June 1944, the patient complained of pain and swelling in the right ankle. The swelling, which was chiefly on the dorsal surface, felt fluctuant. Motions of the ankle were limited. The overlying skin was warm; it was brown in color. Roentgenograms * (Fig. 3) showed marked cystic changes throughout the entire talus; an eggshell-like structure, three centimeters in diameter, was visible in the soft tissue above the anterior margin of the talus. The lungs were free from metastases. On July 15, 1944, a Gritti-Stokes amputation of the right leg was performed under spinal anaesthesia.

Surgical Specimen

Gross Description: The specimen consisted of the right leg and foot. Over the area of the talus and navicular, the foot was swollen and the tissue was fluctuant. The skin was pigmented a deep brown, and was marked by prominent veins. The biopsy scar was present. Sagittal section (Fig. 4) showed that the bony architecture of the talus had been completely replaced by a gray-blue, friable, translucent, lobulated pseudocystic tumor. The articular cartilages of the talus and tibia had been destroyed anteriorly and superiorly by invading tumor, and the joint had been obliterated. The tumor had also invaded the soft tissue of the foot at the talotibial junction, to form a pseudocystic hemorrhagic mass, 5 by 2.7 centimeters in size, corresponding to the swelling noted externally. The mass lay beneath the skin; it extended from the talotibial junction downward over the dorsal surface of the navicular and over one-half of the dorsal surface of the cuneiform. The articular cartilage of the talus posteriorly was destroyed by tumor, and there was invasion of the posterior tip of the tibia, the superior portion of the calcaneus, and the soft tissue, making a pseudocystic mass, 2.5 by 3 centimeters. The tumor destroyed the cartilage of the talus anteriorly and inferiorly, with obliteration of the talocalcaneonavicular joint for a distance of 2.8 centimeters.

Microscopic Description: The marrow spaces were filled by a myxochondrosarcoma. Tumor cells were few in number, and they varied in shape and size; some lay in the spaces. The intercellular substance, in part, appeared like mucin when treated with blue stain; in certain areas, it took a pink stain, like hyaline cartilage. The vessels were dilated. Oedema and pseudocystic formation were present. Focal calcification had occurred. Septa of connective tissue divided the tumor. No osteogenesis could be made out. Preformed bone

* Interpreted by G. N. Scatchard, M.D.

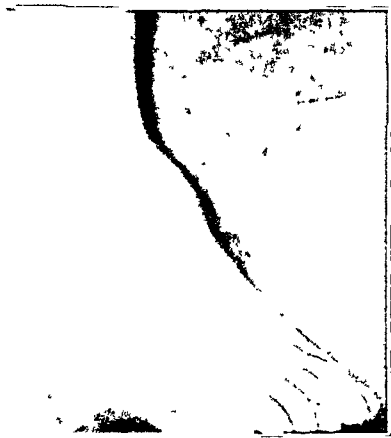

FIG. 1
Lateral aspect of foot.

FIG. 2
Medial aspect of foot, showing biopsy scar.

FIG. 3
Roentgenogram showing changes in talus and overlying tissue.

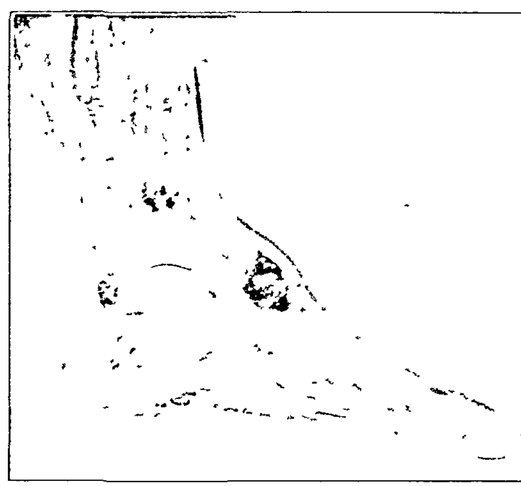

FIG. 4
Sagittal section of foot, showing tumor of talus with invasion of adjacent joints and overlying tissue.

showed destruction with giant cells between the tumor and the bone. The tumor penetrated the articular cartilage and invaded the overlying tissue, where its character was similar to that in the bone. Hemorrhage, and regressive and myxomatous changes, however, were more prominent. The skin revealed slight hyperkeratosis and oedema of the epidermis. In the corium the glands were atrophic, and surrounded by oedema. There was a moderate deposit of melanin. The connective tissue was hyalinized. Focal inflammation was seen, with infiltration of plasma cells and round cells. The perineural tissues were thickened. The muscle fibers were atrophic, and interstitial oedema and fibrosis were present (Figs. 5 and 6).

Postoperative Course

The stump healed without difficulty. No recurrence of the tumor was observed during follow-up examinations. Occasionally the patient complained of epigastric distress. In serial roentgenograms of the chest, the right apical area showed the development of a marked increase in density, with formation of a cavity. Tuberculosis was suspected. A metastatic tumor was not reported in the lungs. Hemoptysis appeared late in 1945 On November 2, 1945, the patient cut his throat with a jackknife. The lacerations and hypopharyngeal fistula were repaired, and a tracheotomy was done. On November 19, the patient died.

Postmortem Examination

An autopsy was performed on November 21 The findings indicated a well-healed stump following Gritti-Stokes amputation of the right leg for myxochondrosarcoma of the talus; metastatic chondrosarcoma of the upper lobe of the right lung with a few small nodules; abscess of the right upper lobe with thrombosis

of the vessels; laceration of neck, severance of epiglottis, and external hypopharyngeal fistula, following attempted suicide; evidence of surgical repair of the lesions just mentioned and of tracheotomy; purulent tracheobronchitis and bronchiolitis; recent bronchopneumonia; chronic peptic ulcer of the duodenum; arteriosclerotic scarring of the kidneys; glandular hyperplasia of the prostate; and slight interstitial fibrosis of the pancreas.

SUMMARY OF FINDINGS

The clinical, roentgenographic, and pathological findings in eleven cases of myxochondrosarcoma are briefly summarized in an attempt to present an inclusive picture of the lesion.

The ages ranged from eleven to sixty-two years; three patients were in the second decade, three in the third decade, three in the fourth decade, one in the sixth decade, and one in the seventh decade. Eight of the patients were males; three were females.

The patients complained that symptoms had been present for periods of from one month to four years. In eight cases, the duration of symptoms was less than one year. Six patients believed that their symptoms were related to a preceding injury. All complained of pain and swelling or a mass in the ankle.

Physical examination disclosed swelling of the foot, chiefly on the anterior dorsal surface of the ankle, occasionally with a palpable mass. Other physical signs included pain, tenderness, and fluctuation of the swelling; limitation of movement of the foot; dilatation of the veins in the overlying skin; and atrophy of the affected leg. The right and left ankles were involved in the ratio of five to four.

Roentgenograms were taken in eight cases. Positive findings for tumor were present in five [3,4,5], including the case presented here. In our case and in three others, biopsy examination permitted a pathological diagnosis of the type of tumor [4,5,8].

When the clinical and roentgenographic impression had been recorded, a tumor was finally diagnosed in six cases. The lesion was confused with a ganglion in one case [9], with tuberculosis in one case [1], and with fracture in one case [2].

Astragalectomy was done in three cases [1,2,9]; the leg was amputated in seven cases, at various sites [3,4,5,7,8]; and curettage was done in one case [3] in which amputation apparently had been refused.

The pathological diagnoses included osteogenic sarcoma in three cases [1,5,8]; myeloid sarcoma in one [9]; giant-cell tumor, probably malignant, in one [3]; myxochondrosarcoma in five [3,4], including the case reported here; and fusiform-cell sarcoma in one [7].

Davidson and Kurtz's patient (giant-cell tumor with probable malignant change) received postoperative roentgenotherapy. Preoperative roentgenotherapy was given in the case of chondrosarcoma reported here.

Six patients, seen from two and one-half months to five years after operation, had no demonstrable recurrences or metastases. Recurrence was noted in the patient with primary chondrosarcoma, where only curettage had been allowed [3]. One patient with chondrosarcoma [3] died three years after amputation with metastases to other bones; in the case described here, pulmonary metastases were revealed at autopsy, seventeen months after amputation.

DISCUSSION

The patient reported here (sixty-two years of age) was the oldest in whom a tumor had been described. Pathologically, this patient represented the fifth case of chondrosarcoma. In an excellent review of chondrosarcoma, Lichtenstein and Jaffe stated that this tumor should be differentiated from osteogenic sarcoma for anatomical, clinical, and prognostic reasons. Chondrosarcomata may be of the peripheral type or, as in our case, of the central type. The belief of Lichtenstein and Jaffe that local trauma is probably not a factor in the initiation of chondrosarcoma or in malignant transformation of enchondroma or osteochondroma had to be evaluated in regard to the medicolegal problem which

Fig. 5

Chondrosarcomatous tissue in marrow spaces (× 30).

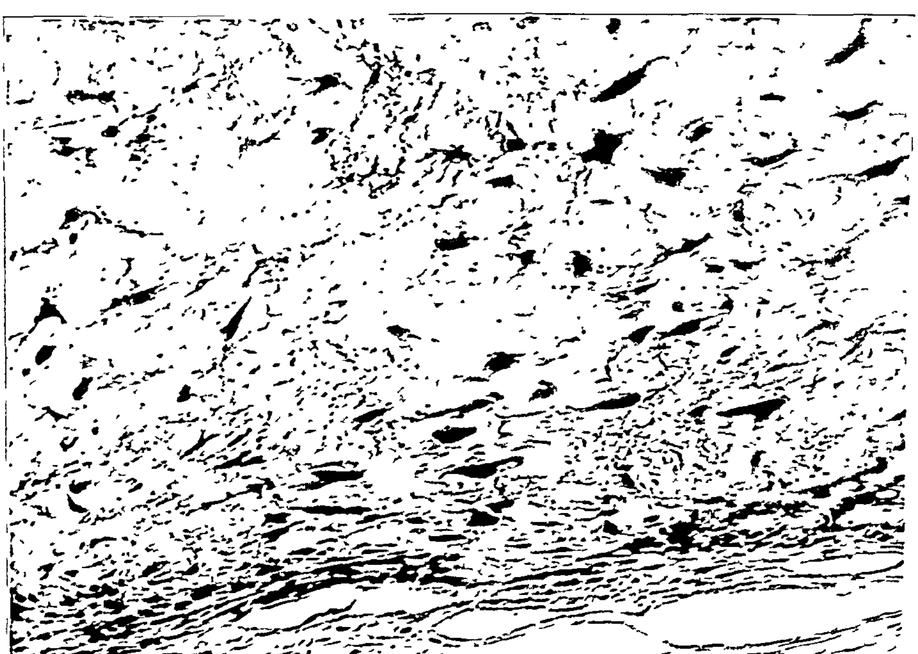

Fig. 6

Myxosarcomatous area after invasion of soft tissues (× 75).

was raised in our patient by the history of trauma. Noteworthy in this case was the extension of the tumor to the overlying soft parts to form a fluctuant, pseudocystic. hemorrhagic mass which, with the bone destruction, gave suggestive roentgenographic eviden

No other patient mentioned in the literature received roentgenotherapy before operation. Whether this treatment had any effect upon inhibiting the growth and spread of the tumor, or upon producing regressive changes in the tumor, remained a matter for speculation; the radiation did not destroy the tumor. Chondrosarcoma has been thought to be radioresistant.

In chondrosarcoma of one of the bones of the foot, amputation above the ankle joint is advised, rather than local excision.

Our case illustrated that, as in other bones, chondrosarcoma of the talus runs a slow course with metastases, chiefly by way of the veins, to the lungs and heart. Our patient was followed for three and one-half years from onset of symptoms to death as a result of suicide. In no previously reported case of chondrosarcoma of the talus was an autopsy performed or was the patient proved to have visceral metastases.

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LAMINAGRAPHY THROUGH PLASTER CASTS IN POSTREDUCTION ROENTGENOGRAPHY OF CONGENITALLY DISLOCATED HIPS

BY BERNARD S. EPSTEIN, M.D., BROOKLYN, NEW YORK

From The Jewish Hospital of Brooklyn*

A vexing problem often encountered by orthopaedic surgeons concerns the alignment of the femoral head and acetabulum, after reduction of congenital dislocation of the hip and fixation of the limb in a plaster cast. Overexposed roentgenograms, taken with the use of the Bucky diaphragm, have for the most part been inadequate. This difficulty can be surmounted by the use of laminagraphy.

Our present technique, carried out with the use of the Kieffer laminagraph, employs a five-turn spiral motion, 150 milliampere-seconds, 55 to 60 kilovolts, target-film distance of 30 inches, and parspeed screens. Sometimes the five-second exposure is too long for the patient to be kept quiet, but, if the examination is performed while the child is anaesthetized, this difficulty may be overcome. Otherwise, a two-second exposure with two spiral

* Radiologic Service of M. G. Wasch, M.D.

FIG. 1-A

The alignment of the hips cannot be adequately seen on the postreduction roentgenogram through the plaster cast.

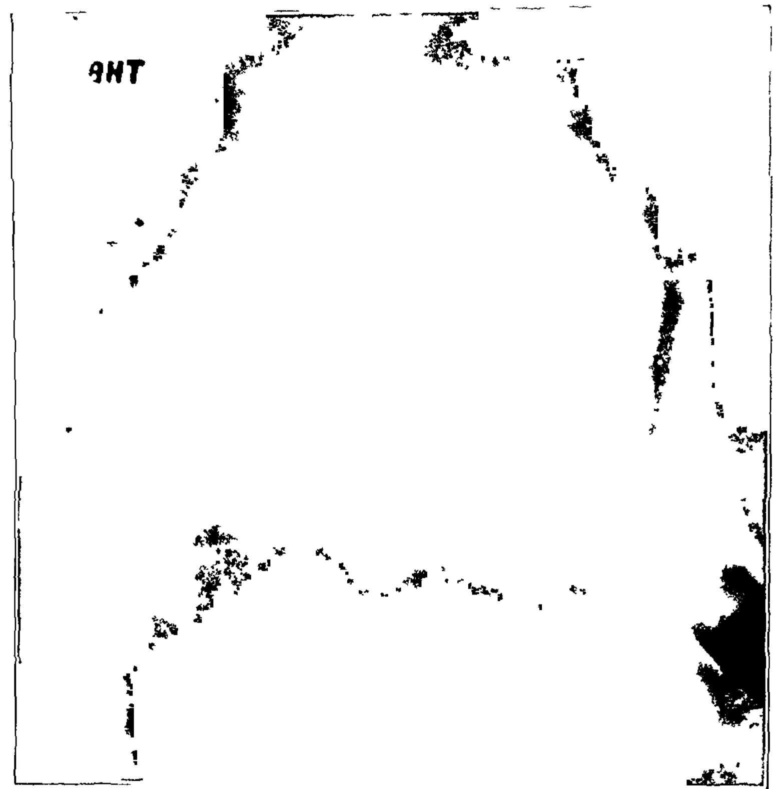

FIG. 1-B

Laminagram, 5 centimeters above the table top, shows that the dislocation of the right hip has not been satisfactorily reduced. The femoral head is rather high. Note the clarity of the shadow of the femur.

turns is made, the kilovoltage or milliampere-seconds being raised to compensate for the diminished exposure.

It is advisable to make a preliminary laminagram, based on an estimation of the height of the hips from the table top. Inspection of the wet film will determine whether or not the proper plane is in focus, and succeeding exposures can be made, as necessary. In infants examined at this Hospital, the hips were usually brought into sharp focus at from 4.5 to 6 centimeters from the table top. Occasionally, the femora will be so fixed that they are in slightly different planes. Separate exposures are then required, each thigh being positioned so that the hip and femur lie parallel to the cassette. Attendants holding the child should wear lead rubber gloves.

Laminagraphy is a useful adjunct to roentgenographic examinations of patients with plaster casts. The elimination of superimposed shadows makes it possible to examine bony structures more accurately than can be done on routine roentgenograms.

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BILATERAL OSTEOCHONDRITIS OF THE TARSAL NAVICULAR AND THE FIRST CUNEIFORM

A Case Report

BY ARCH F. O'DONOGHUE, M.D., EDMUND S. DONOHUE, M.D., AND WAYNE W. ZIMMERMAN, M.D., SIOUX CITY, IOWA

Osteochondritis has been found in most of the bones of the body. Harbin and Zollinger, in 1930, reviewed almost 700 articles written on the subject. To our knowledge, only one case of bilateral osteochondritis of the tarsal navicular and the first cuneiform has been reported. Buchman, in 1933, reported two cases of osteochondritis of the first cuneiform. In one of his cases, there was bilateral involvement of the first cuneiform and changes in the tarsal naviculars, suggestive of osteochondritis. Lewin mentioned a case of osteochondritis of the second cuneiform, and Wagner reported a case in the third cuneiform.

Case 1. A white boy, aged three, complained of slight pain in the left foot, which caused him to limp. His parents brought him for examination on March 28, 1946. His past history and a complete inventory of his symptoms were essentially negative. Physical examination revealed a well nourished boy with no evidence of disease in the back, hips, knees, or feet. Roentgenographic examination showed that the first cuneiforms of both feet had a fragmented, moth-eaten appearance. The right tarsal navicular was shown to be developing from two tiny centers of ossification; the left was developing from one (Fig. 1).

FIG. 1

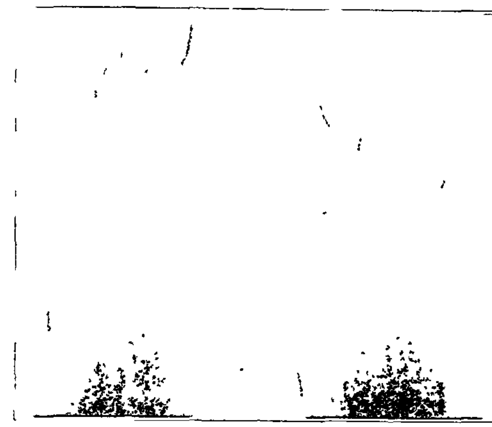

FIG. 2

Fig. 1: Roentgenogram, March 28, 1946, showing early bilateral osteochondritis of first cuneiforms.
Fig. 2: Roentgenogram, March 20, 1947, showing osteochondritis of first cuneiforms and naviculars of both feet.

The patient's feet were fitted with Whitman plates. He was seen occasionally thereafter. On March 20, 1947, one year after his first examination, roentgenograms showed that the condition in the cuneiforms had improved, but was still present In addition, both tarsal naviculars showed evidence of fragmentation. They were not yet completely ossified (Fig. 2). Supportive plates were continued.

COMMENT

Primary osteochondritis involves the primary ossification centers; secondary osteochondritis involves the secondary centers, epiphyses and apophyses. The involvement of more than one bone by the osteochondritic process is not uncommon. In one of Köhler's first cases, described in 1908. there was involvement of the navicular and the patella. This multiplicity of bone involvement suggests some systemic factor as an etiological agent. The etiology is yet to be proved. Trauma, which is too often considered the cause of any disease of unknown etiology, probably plays an insignificant role. Since the disease is self-limiting and does not require surgery, there is a scarcity of pathological material from early cases of primary osteochondritis. Supportive treatment is all that is indicated.

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ANVIL FOR BONE SURGERY

BY STERLING BUNNELL, M.D., SAN FRANCISCO, CALIFORNIA

An essential for cutting a bone with an osteotome is to have the bone held solidly, in order to eliminate all yield as the tool cuts. The mechanic places a heavy weight, or anvil, behind the piece to be cut, so that the inertia of the hammer is neutralized by the inertia of the weighty anvil.

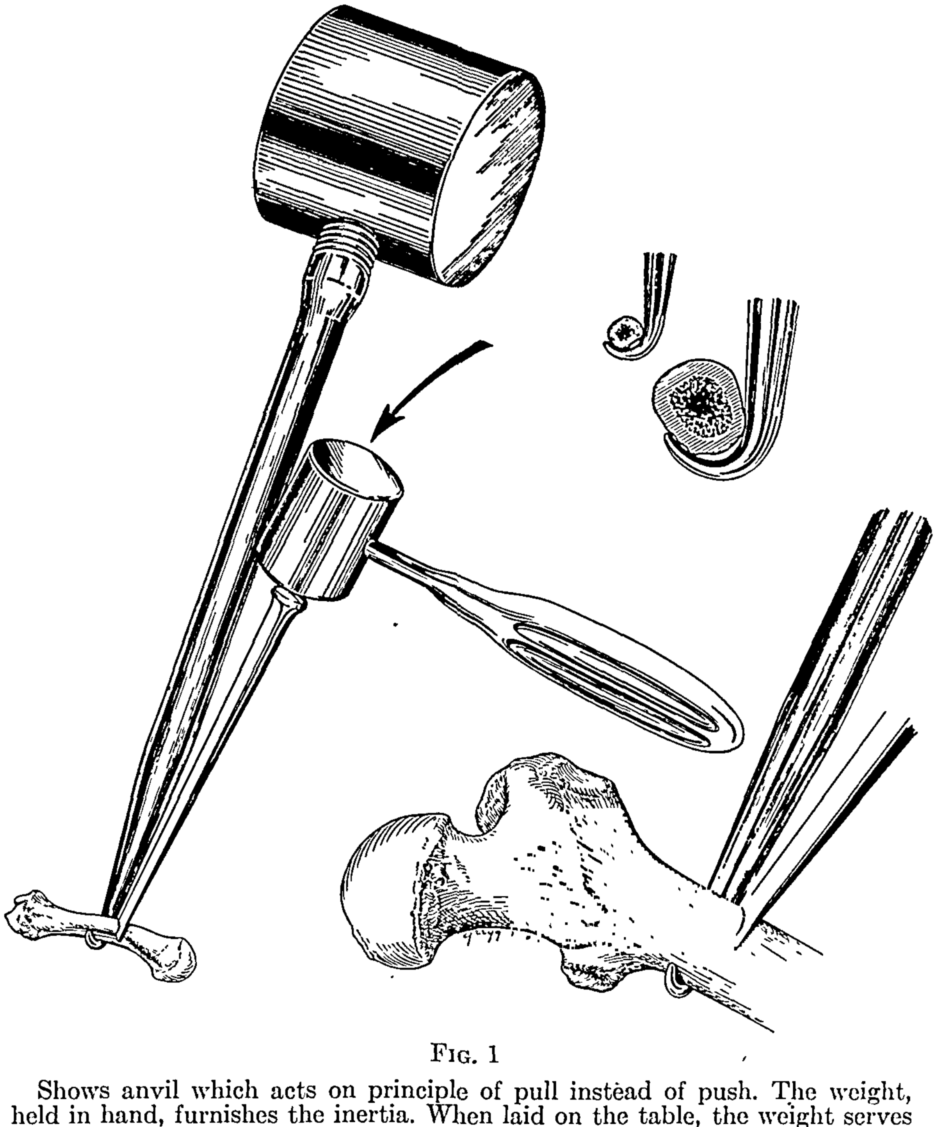


FIG. 1

Shows anvil which acts on principle of pull instead of push. The weight, held in hand, furnishes the inertia. When laid on the table, the weight serves as a chopping block for shaping bone grafts.

A slender point of a conventional anvil, placed beneath the bone, gives satisfactory results. This requires, though, a rather free exposure of the bone, in order that the anvil may be thrust under from one direction and the hammer applied from another direction, at an angle of 90 degrees with the first.

The anvil shown in Figure 1 was developed after long use of the type just mentioned. It can be used through a small exposure, and furnishes full inertia. Into an iron mass is screwed a long slender rod, or handle, which tapers and terminates in a hook. The hook is so shaped that it can slip through a small wound and curve around the bone, backing it up. The anvil is held firmly by an assistant. Only one retractor is needed. The inertia of the small hook is comparable to that of the weighted end of the anvil. Both the osteotome and the stroke of the hammer should exactly parallel the handle of the anvil.

This anvil gives just as much support to the bone as the conventional type, but it is on the principle of pull instead of push. The handles, threaded so as to be detachable from the weight, are of graded sizes, so that the hook will fit any bone from a phalanx to a femur.

A PLASTIC OPPONENS SPLINT FOR THE THUMB

BY JOHN E. STEWART, M.D., BOSTON, MASSACHUSETTS

From the Orthopaedic Service, The Children's Hospital, Boston

A method has been developed for producing an opponens splint of plastic material, which utilizes the *cire perdue* or "lost-wax" process of casting a mold, a process known to the Chinese for at least two thousand years.

A pattern is first cut from a sheet of wax, and is then molded over the hand into the desired shape. This wax model is then cast in plaster and boiled out (from whence the process gets its name of *cire perdue*). The resulting mold is packed with dental acrylic and is then heat processed. The finished product is a light, waterproof, durable splint, suitable for patients who are handicapped by paralysis of the opponens muscle of the thumb.

FIG. 1

FIG. 2

Fig. 1: Two of the three pattern sizes used, with a five-centimeter rule for size comparison.

Fig. 2: Plastic opponens splint in place upon the hand.

The technique is not easy, but can be mastered by a technician familiar with the use of wax and plastics. This splint has been used in the Massachusetts Infantile Paralysis Clinic of the Boston Children's Hospital for the past two years and has been found of value. Some of the original splints are still in use.

It is hoped that presentation of this method of making plastic splints will stimulate additional use of plastics in the field of orthopaedic appliances.

BRACE FOR EXTENSION OF THE SPINE

BY ROBERT W. AUGUSTINE, M.D., OAK RIDGE, TENNESSEE

The purpose of this brace, which is a combination of the three-point brace and the Knight spine brace, is to hold the thoracic and lumbar portions of the spine at a fixed degree of extension. It is not intended as a means of reducing fractures of the spine. The brace is applicable for treatment of the ambulatory patient with a fracture of the thoracic or thoracolumbar area of the spine, and for the ambulatory patient with Pott's disease or senile osteoporosis. It may have other applications.

The Knight spine brace obtains a firm grip of the lumbar spine and the pelvis, and serves as a foundation for the application of the arms of the three-point brace. The Knight brace also gives lateral stability. Extension is maintained through a low abdomino-pubic pad and a pad over the upper portion of the sternum. The three points necessary to hold the spine in extension are then represented by the pubic and sternal pads and the lumbar Knight brace. The sternal and pubic pads are held in place by arms, extending from each side and connected to the lateral longitudinal bars of the Knight brace through a special joint (Figs. 1, 2, and 3). Extension of the spine is maintained by a turnbuckle on each side,

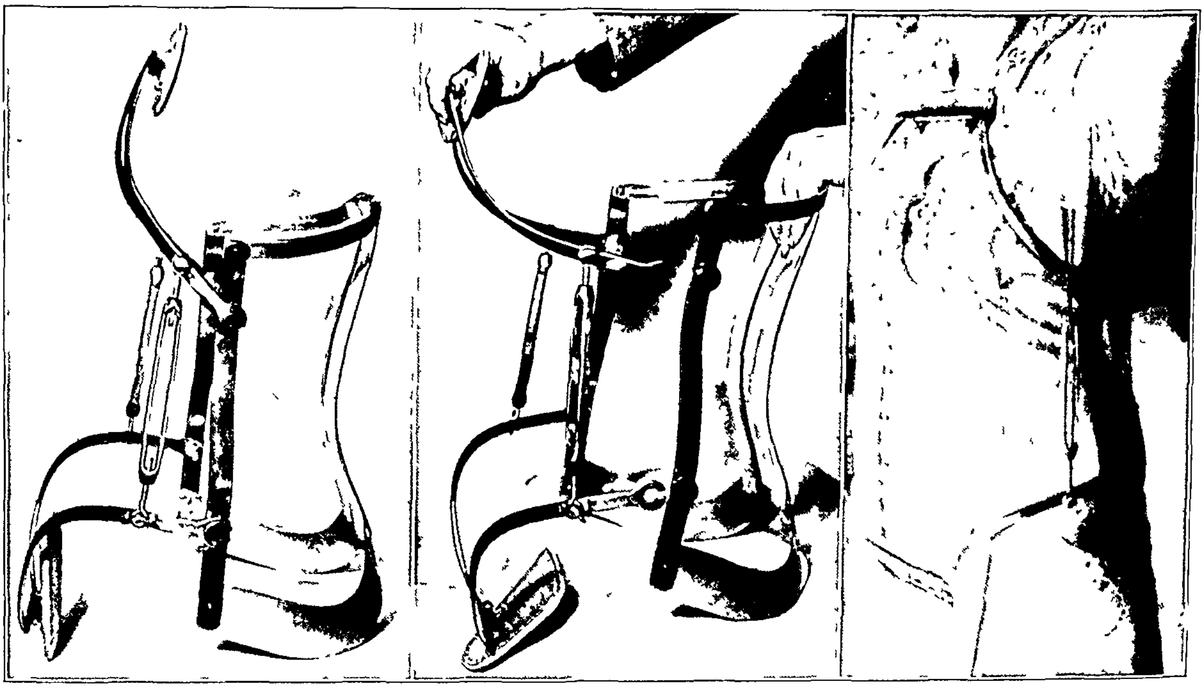


FIG. 1 FIG. 2 FIG. 3

holding the upper and lower anterior arms in extension. The arms of the three-point brace do not touch the body except through the pads. The Knight brace is open in back and is connected across the abdomen by a lacing corset.

The complete brace weighs about three pounds and may be worn under the outer clothing. The two anterior arms of the three-point brace, with their pads, are easily detachable. The author knows of no other brace that will hold the thoracic spine in extension in a practical manner and yet be easily removable.

Both the Taylor brace and the axillary crutch brace act upon the shoulder girdle, and are not effective in maintaining extension of the thoracic spine. The "Walter Reed" brace and the "butterfly" brace (essentially a Knight brace with bilateral fixed arms, extending to just below the clavicles, to hold the spine extended) are difficult for the patient to get in and out of, are not adjustable, and lack the necessary pubic point of pres-

sure. The three-point brace, described by Baker [1] is effective in patients with a stiff spine (Marie-Strumpell arthritis), but will not stay adjusted, in our experience, on individuals with a supple spine. It lacks a firm grip on the trunk

Difficulties with fabrication and cost have limited the use of this brace, so that the author's experience with it is not extensive It has, however, been found effective in maintaining extension; and its light weight, adaptability, and ventilation offer advantages over plaster. It has sometimes been found necessary to fix the degree of extension by locking the turnbuckle, so that the patient will not alter the brace in order to make sitting more comfortable

NOTE: This brace was produced by the author in collaboration with Mr Charles Ross, bracemaker On May 7, 1947, after this description of the brace had been prepared, a brace designed by Eugene L Jewett, M.D , of Orlando, Florida, was discovered to be similar in principle and construction The differences between the two were sufficient, however, so that publication of this statement was considered to be justified

1. BAKER, L D Rhizomelic Spondylosis Orthopaedic and Roentgen Therapy J Bone and Joint Surg, 24: 827-830, Oct 1942

MODIFICATION OF THE SMITH-PETERSEN NAIL AS USED WITH THE THORNTON PLATE

BY PHILIP R. FREDERICK, M.D., EVANSTON, ILLINOIS

Occasionally, the screw which fastens the Thornton plate to the Smith-Petersen nail becomes unscrewed and allows the two to separate; this often necessitates a second operation. To overcome this difficulty, a revision in design of the connection is offered, which, the author believes, will make it more secure.

By this plan, the base of the flanged nail is threaded for two nuts. The plate is slipped over this base and held by two nuts which are tightened in place with a socket or box wrench, the second nut serving to lock the first. The threaded portion is drilled at a level just behind the nuts, so that a small wire may be inserted at this point to further insure against loosening (Fig. 1).

Several advantages of this design are evident:

1 The greater diameter of the threaded area allows greater surface contact of the threads and more threads per inch, thus making the union tighter than with a screw.

2. The nuts can be fastened much tighter with a socket wrench than a screw can be turned with a screw driver.

3. This arrangement does not interfere with bending the plate to obtain the exact angle desired.

4. The wire through the shaft of the threaded portion behind the nuts is a further locking measure.

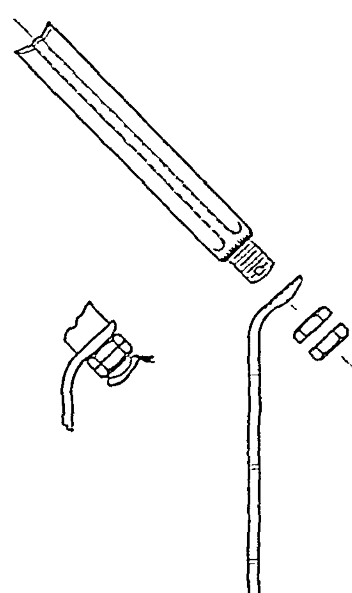


FIG 1

GUIDE FOR DRILL OSTEOTOMY

BY VINCENT E. LEGGIADRO, M.D., PORT CHESTER, NEW YORK

The danger of splintering of bone and consequent loss of the desired angulation after osteotomy is too well known to require further elaboration. To avoid this complication, experienced orthopaedic surgeons now resort to the multiple-drill method, which permits accurate shaping of the ends and minimizes the danger of splintering. In order to simplify the procedure and reduce the duration of the intervention, the instrument described here has been adopted and found of value.

The instrument (Fig. 1) is composed of a handle which holds, at its extremity, a circular perforated steel block (*F*) which is placed at an angle of 125 degrees to improve the view of the operative field. This block contains a guide (*H*) and an adjacent drill (*G*). Both guide and drill can be turned in any direction, to suit the needs of the surgeon.

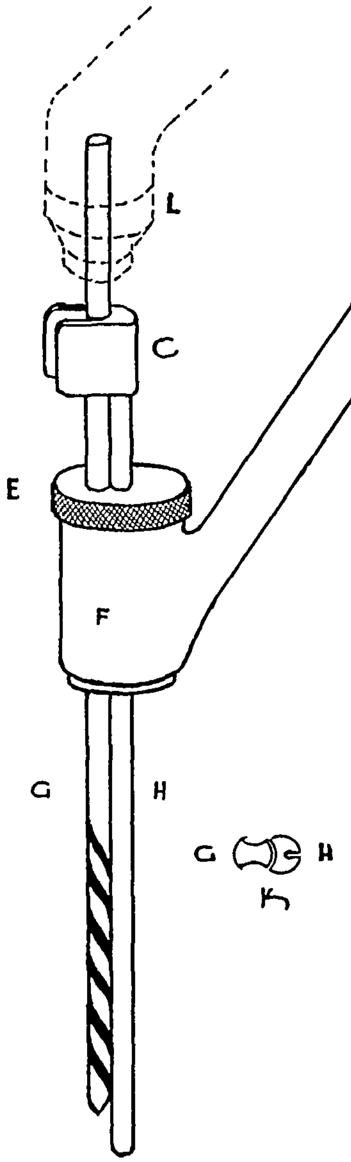


FIG. 1

Fig. 1: Drawing shows instrument, five-sixths of actual size. *A:* Handle; *B:* Lock screw (for perforated steel block); *C:* Upper guide of drill; *D:* Connecting rod; *E:* Guide lock; *F:* Perforated block; *G;* Drill; *H:* Drill guide; *K:* Cross section of drill and guide; *L:* Drill chuck.

Fig. 2: Sample of consecutive perforations made by drill guide. No web is left between perforations.

The first hole can be made at any point in the bone to be severed. It is preferable to start at its center, where the bone is thickest, and from there to proceed in any direction desired, for different types of osteotomies. The guide is introduced into a hole previously made, and the depth is measured. By turning a knurled ring (*E*), the guide is locked in position, and successive holes are made until the entire bone has been severed. After the drill and guide have been placed in position, the surgeon can manipulate the instrument with one hand because (1) the drill is doubly guided at its proximal and distal ends; and (2) the distance between the chuck holding the drill and the proximal end of the guide measures, at any time, the remaining depth of the bone to be perforated. There is no danger of drilling be-

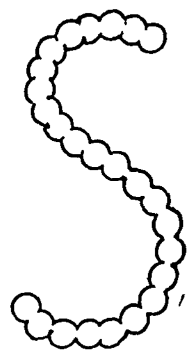


FIG. 2

yond the posterior wall of the bone. With this instrument, all types of osteotomies can be performed, especially a U or V osteotomy in a deep-seated bone; and the greatly desired interlocking of the fragments, to maintain an accurate position without danger of slipping, is possible.

The instrument is equipped with drills of three sizes, for adaptation to the different thicknesses of bone to be severed. They are all provided with carbide tips, to maintain a constant sharpness and to reduce to a minimum the heat produced. The entire instrument, with its attached motor, weighs only half a pound. The drill may be driven by a small electric motor or by a flexible cable.

DRIVER FOR NEUFELD NAIL

BY GOTTLIEB S. LEVENTHAL, M.D., PHILADELPHIA, PENNSYLVANIA

The Neufeld nail for intertrochanteric fractures has been used in almost all such fractures treated in the Orthopaedic Service of the University of Pennsylvania Hospital. After reduction of the fracture, a heavy Kirschner wire is inserted through the middle of *the neck, the Larsen guide being used. The bottom of the V of the Neufeld nail is then* placed against the Kirschner wire and the nail is driven in.

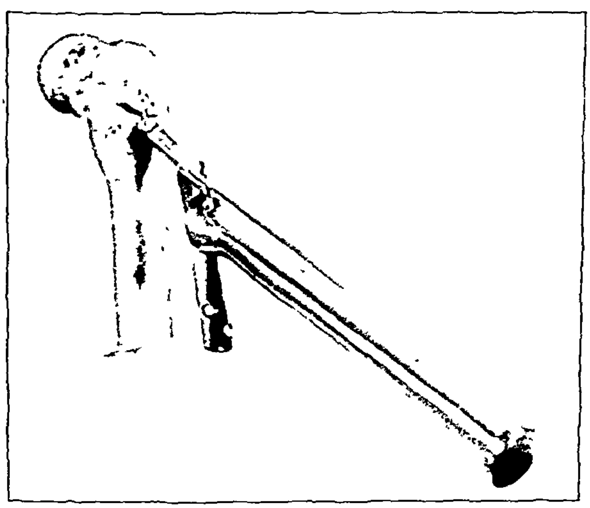


FIG. 1

Neufeld nail being driven in, with Kirschner wire used as guide.

With this method of nailing, proper placement of the nail is quite easy, but the procedure is complicated because the type of driver available is so constructed that it strikes the end of the Kirschner wire. As a consequence, the wire has to be bent out of the way. This destroys, partially at least, the visual guidance it is supposed to afford.

A driver has been constructed which permits the Kirschner wire to remain in place, and which does not interfere with driving the nail along the line of the wire. The portion of the driver which holds the Neufeld nail is made of angle iron. To this is brazed a long rod, so that the rod and the V part of the nail are parallel when the nail is screwed to the angle part of the driver. At the driving end of the rod, a flanged piece of steel is brazed to afford a better driving surface. *It can also be used as an extractor of the nail by driving on the reverse side.*

A SIMPLIFIED SPRING BRACE FOR DROP-FOOT

BY LYMAN SMITH, M.D., ELGIN, ILLINOIS

In many cases of equinus deformity, whether caused by spastic or flaccid paralysis, or by structural changes, some type of corrective walking brace is frequently useful. The brace described here shows marked advantages over other types of braces being used.

The spring brace is easily applied to any stiff-shanked shoe; the only tool necessary is a drill. Once the original fastening has been accomplished, the brace may be transferred from one shoe to another, in a few seconds. The brace weighs only five ounces, yet it is durable, for it has withstood the equivalent of 100,000 miles of walking in machine tests. The coil spring is hidden anterior to the heel of the shoe, making the brace less conspicuous and also lessening the possibility that the wearer's trouser cuff will catch on the brace and trip him, as has been the case with the older type of brace. The spring is designed to lift eleven pounds. By bending the uprights of the brace forward or backward, the lifting requirements can be increased or decreased. The brace can be modified to resist a varus or valgus deformity, as well as an equinus deformity, by interposing a coil spring between one of the uprights and the medial or lateral border of the shoe. The saddle posterior to the calf is made without an anterior strap, so that if the wearer squats, the uprights will not move forward and impinge on the malleoli.

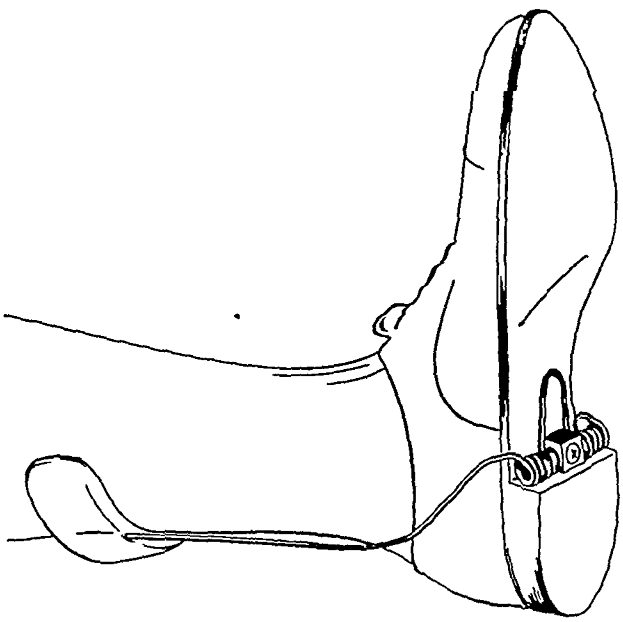


Fig. 1

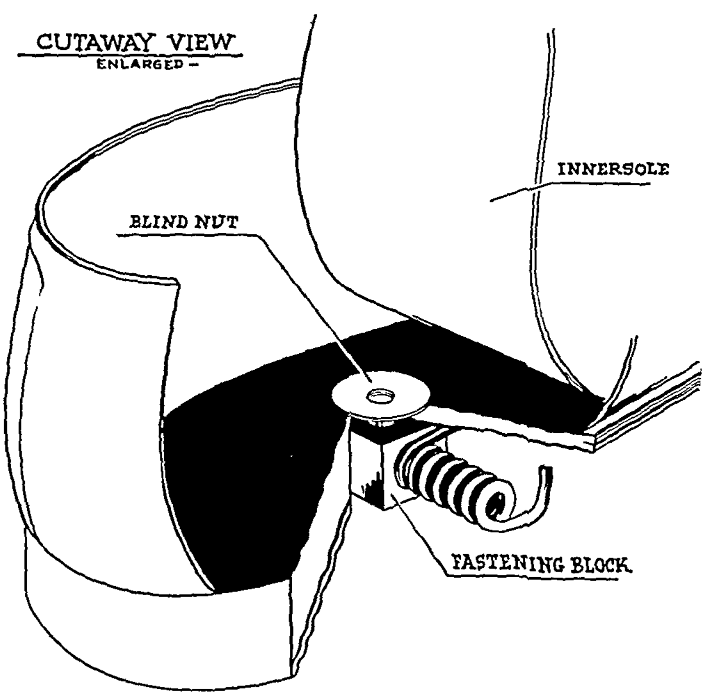


Fig. 2

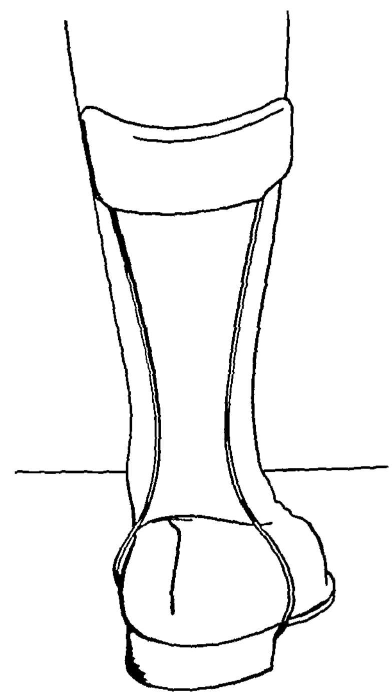


Fig. 3

The splint is simple in construction (Figs. 1, 2, and 3). The uprights and the coil spring are made from a single piece of spring wire. The wire is welded to a pliable section of mild steel, padded with sponge rubber to form the saddle behind the calf. This flexibility is desirable so that the saddle may conform to any size of leg. The brace is attached to the shoe by means of a single screw, which passes through a fastening block, and is applied to a blind nut placed under the inner sole of the shoe (Fig. 2). The spring is attached to the fastening block by means of two anchor studs; the loops of the spring rotate around those studs.

NOTE: This brace was developed with Mr. O. S. Caesar, Barrington, Illinois.

DISCUSSION

SURGICAL TREATMENT OF INTRACTABLE PLANTAR WARTS

(Continued from page 760)

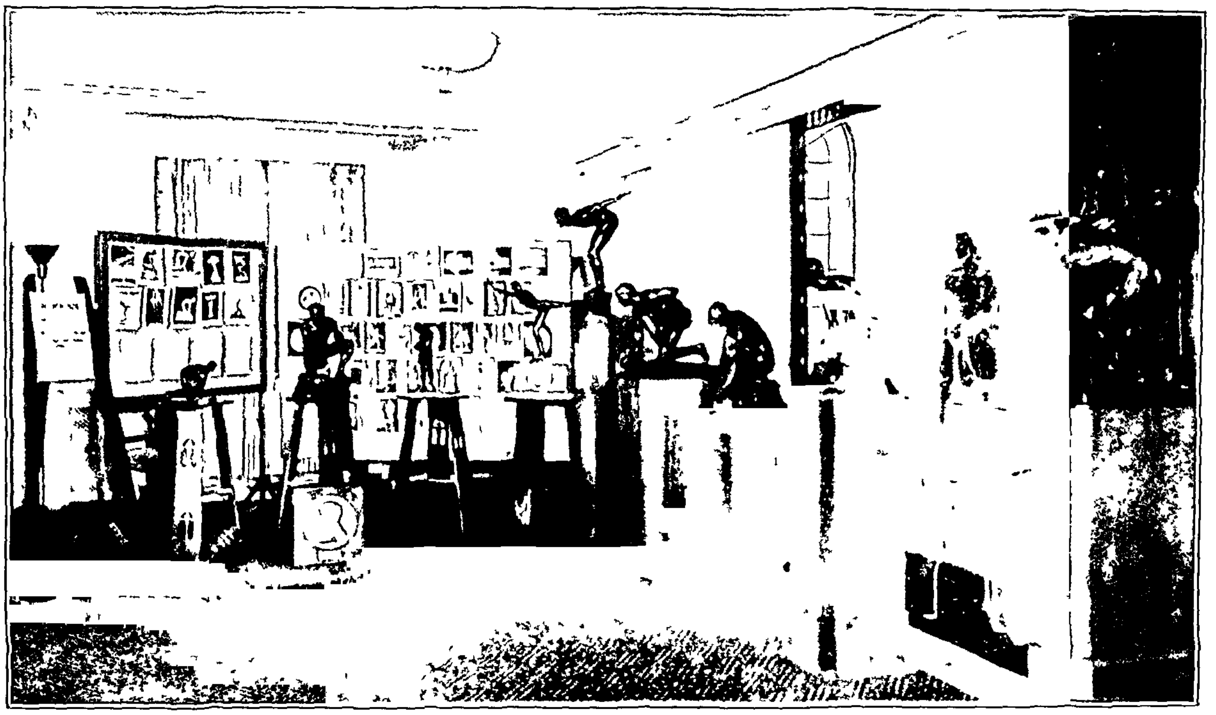
DR. E. B. MUMFORD, INDIANAPOLIS, INDIANA: I have been doing this same operation for eight or ten years, with great success. The only objection to Dr. Dickson's procedure is the extensive operation, which is not necessary. All you need to do is to make a small incision at the top of the foot, remove the head of the metatarsal, and then make a small incision and take out the corn. The patient will get well with a very small scar. In regard to Dr. Thomson's remarks, multiple warts can be cured by roentgen rays.

DR. A. W. FARMER, TORONTO, ONTARIO, CANADA: I would like to congratulate Dr. Dickson on the procedure. I agree with Dr. Key that this is a formidable procedure for a small lesion. We found that some of these cases could be cured by removing the pressure points or by excising a piece of the head or all of the head, removing the wart, and filling in the cavity by an S-shaped plastic manoeuvre. The flaps should extend completely across the foot. The flaps must be undermined adequately and shifted without tension. Sometimes a single rotation flap of the sole of the foot is adequate.

DR. JAMES A. DICKSON (closing): I have done some operations where I removed the head of the metatarsal only, but the results were not so satisfactory as in those where the toe and shaft of the metatarsal were removed. The toe has no function when the head of the metatarsal is gone, and the foot looks more normal than when the toe is retained.

Dr. Schwartz asked how long these cases have been followed. The first one was done in 1940 and we have followed them since that time. As far as I know, there has been no recurrence of the old lesion.

I agree with several of the speakers that we are not dealing with a primary wart lesion. The continued use of roentgen rays and radium has brought about destructive lesions that give rise to the deep ulcerations. The operation suggested not only removes the wart, but also the destructive lesion.



THE MOULDER OF CLAY AND OF MEN

TAIT MCKENZIE

1867–1938

The illustration portrays sculptured bronze as arranged in an exhibition presented by the Canadian Orthopaedic Association at the Orthopaedic Congress at the Chateau Frontenac, Quebec City, Quebec.

Tait McKenzie was born May 26, 1867, "a son of the manse", at Almonte, Ontario, in the Township of Ramsay. When he was nine years old, his father died, but his home life continued one of cultural development. In some manner, his Highland mother found the funds to keep her three children in school until they had university degrees. Tait McKenzie entered McGill in 1885 and, by vacation earnings, "worked his way through" and was graduated in medicine in 1892.

He was demonstrator in anatomy and became the first Medical Director of Physical Education in McGill University, remaining there until 1904, when he became Professor of Physical Education at the University of Pennsylvania. During part of his war service with the Royal Army Medical Corps, he was on command to the Canadian and later the American medical organizations. His essential service was to develop all of the rehabilitation agencies which featured the later periods of World War I and were basic for the subsequent progress of World War II. In this he was associated with Sir Robert Jones.

His life-time philosophy was to present human life in its finest physical state. He was humanist before being artist. His first efforts were portrait plaques; then the three-dimensional qualities intrigued him and he sought the perfect youth in a form derived from the composite of multiple exact measurements of hundreds of different athletes. The statues of the "Athlete" and the "Sprinter" are examples of this scientific approach to his art. This method was shortly abandoned, and the individual features of a particular athlete were then to be portrayed. He was convinced that the most potent humanizing influence is a healthy zest for games. Thus he will be known as "The Sculptor of Youth".

The post-war period saw the introduction into his work of the War Memorial, and patriotic youth was portrayed in the mantle of "living clay and willing sacrifice". The trinity of these major works are international in distribution,—"The Victor" in Woodbury, New Jersey, "The American-Scottish" in Edinburgh, and "The Volunteer" in his native village of Almonte. The latter has an interesting story. At a time when the sentiment for war memorials was misguided in regard to quality and design, the sponsors of the memorial sent two representatives to London, England, to choose a suitable artist to memorialize the fallen of their district. There they visited the Grafton Gallery where an exhibition was in progress, and they found the artist to be their own townsman!

To the University of Pennsylvania belongs the honor of the collection and establishment of the major portion of the sculptured works of the artist. The Orthopaedic Associations are grateful that the kindness of the University, and of the National Gallery of Canada, made it possible that the exhibit might be presented to the Orthopaedic Congress of the three nations.

Quoting from "Tait McKenzie" by Christopher Hussey: "The athletic cult cannot fail to change human conditions. Athletics and games, combined with science, may yet prove a salvation to a distraught world and an alternative to a mechanical civilization that tends to suppression of human characteristics."

George A. Ramsay, M.D.
London, Ontario

JAMES O. WALLACE
1877–1948

Dr. James O. Wallace died on February 7, 1948, at the age of seventy-one years, at his home in Pittsburgh. His daughter, Betsy (Mrs. Thomas G. Greig, Jr.), with her husband and two children, were living with him. His wife, Edith Boswell, died in 1913.

Dr. Wallace was born in Pittsburgh on January 17, 1877. He was graduated in 1902 from Kenyon College in Ohio, at which time he was elected a member of Phi Beta Kappa. He received his medical degree from the University of Pennsylvania in 1906. After serving a hospital internship, he became associated with the late David Silver, one of the pioneers of orthopaedic surgery in this country. It was about this time that operative orthopaedic surgery began to develop rapidly, and Dr. Wallace soon became a leader in this new field of surgery in his own community.

He was a member of The American Orthopaedic Association, a diplomate of the American Board of Orthopaedic Surgery, a member of the American College of Surgeons, the Pittsburgh Academy of Medicine, and the Eastern States Orthopaedic Club. He served on the staffs of Mercy Hospital and the Children's Hospital and was an Assistant Professor of Orthopaedic Surgery in the University of Pittsburgh. In addition to his work in his own city, he organized and conducted State clinics for crippled children in numerous counties in western Pennsylvania, under the auspices of the County Societies for Crippled Children.

He worked hard and he kept abreast of the times, but he was not a prolific writer. His most valuable paper was on the treatment of fractures of the spine, in which he had a large experience from his work among the coal miners of western Pennsylvania.

On the day of his death, he operated in the morning and attended his office in the afternoon. On reaching home, he said he was very tired and went to bed. A few hours later, his daughter found that he had died in his sleep.

Dr. Wallace was one of that group of surgeons, of whom only a few remain, who helped to bridge the gap between the older conservatism and the new and brilliant progressionism of orthopaedic surgery. He did much to enlarge and establish this specialty among the people of his community, and to foster and encourage the interest of the public in the care of crippled children.

WILLIAM DARRACH
1876–1948

Dr. William Darrach died on May 24, 1948, after a brief illness.

He was born in Germantown, Pennsylvania, the son of William and Edith Romeyn Aertson Darrach. He attended Hill School and was graduated from Yale University in 1897. Following his graduation from the College of Physicians and Surgeons in 1901, he served an internship at the Presbyterian Hospital. From 1903 to 1909, he served as demonstrator in the Department of Anatomy. In 1913, he was appointed Associate Attending Surgeon at the Presbyterian Hospital, and continued to serve there in varying capacities until his death.

During World War I, Dr. Darrach went overseas with Base Hospital 2, serving as Chief of Surgical Service, later as Consulting Surgeon for the First Army, and, still later, for the Third Army. He was discharged, after serving with distinction, with the rank of Colonel.

In World War II, Dr. Darrach served as Civilian Consultant to the Surgeon General. His final service to the government was in the post of Director of Education and Research at the Kingsbridge Veterans Administration Hospital.

Between the wars, Dr. Darrach served for eleven years as Dean of the College of Physicians and Surgeons. After his retirement as Dean, following the completion of the great Columbia-Presbyterian Medical Center which towers over Washington Heights, his colleagues attested in formal resolution that he, above all others, had been responsible for the successful alliance between the Presbyterian Hospital and other hospitals and the School of Medicine, resulting in the Medical Center.

Dr. Darrach then returned from administration to his real abiding interest—surgery—and established the Fracture Service. To the mending of broken bones, he brought his keen analytical mind, his mature judgment, and rare skill. His interest in his younger colleagues and pupils was boundless. Many of them caught some of the fire of his inspiration, and, through those who did, his influence will continue.

Dr. Darrach was distinguished in every stage of his career, and his pre-eminence was recognized by countless honors. He served as President of the Association of the American Medical Colleges, of the American Surgical Association, and of the Society of Clinical Surgery. He was a Regent of the American College of Surgeons. He was an honorary member of The American Academy of Orthopaedic Surgeons. He was a trustee of Vassar College. He received many honorary degrees from universities at home and abroad. He wrote numerous articles, and always spoke clearly, intelligently, and with a delightful sense of humor. He was a devoted, radiant, and generous person, loved by countless friends, among whom were his many patients and associates.

The New York Herald-Tribune of May 26, 1948, paid this great doctor a final editorial tribute, in part as follows: "To his friends he continued without break an entirely delightful being. For his utter devotion to his tasks, for his unending generosity to the afflicted, it is hard to find a better word than noble, yet his was a nobility that originated from the core of his nature, that was matched by simplicity. . . . No wonder he was loved by all who knew him, as are few men in any generation."

The following letter is reprinted, by permission of the American Medical Association, from the Correpondence Department of the *Journal of the American Medical Association*, vol. 135, p. 531, 1947:

COMPLEX SIMPLE FRACTURE *

To the Editor: Realizing that the term "simple fracture" as generally defined is thoroughly inadequate to describe the trauma received in many so-called simple fractures, I have added a new definition to the simple and compound fracture nomenclature, i.e., "complex simple fracture".

A complex simple fracture is a fracture which is not compound but which has received severe trauma to either or all of the surrounding soft structures, i.e., skin, muscles, blood vessels and nerves. The bony fragments usually are displaced to a marked degree.

"Complex", as defined by "Webster's New International Dictionary", unabridged, is as follows: (1) an assemblage of related things; (2) a whole made up of complicated or interrelated parts.

The complex simple fracture should be further described as to the type of bony injury, for example: complex simple fracture (transverse, comminuted, spiral or oblique, as the case may be).

Through personal contacts and correspondence with the personnel of the three National Fracture Committees (American Medical Association, American College of Surgeons and American Academy of Orthopaedic Surgeons) with reference to their opinions and the necessity for such new fracture term or definition, there was unanimous agreement that such a definition of complex simple fracture was a necessary one and should be generally accepted and used in its broad meaning.

I make an appeal that this new fracture definition or its relative equivalent be used by the members of the medical profession. Besides expressing more adequately the pathologic process in such type fracture it will mean improved records for the hospitals and convey a better description of the fracture to the insurance companies, compensation boards and other related agencies, thereby being of much help to the patient, the physician and every one concerned.

I will appreciate any opinion or suggestions relative to the foregoing.

H. Earle Conwell, M.D., Birmingham, Alabama

* Read before the Boston Orthopaedic Society, October 20, 1947.

CORRECTION

An error was made in the editorial entitled "Congenital Dislocation of the Hip", by A. Bruce Gill, M.D., which appeared in the April 1948 issue of *The Journal*. The sentence beginning on the next to last line of page 526 should read as follows: "Some of these probably recover spontaneously; many of them recover rapidly after birth as a result of a minimal term of treatment by abduction; perfect hips develop in at least a few of them only after prolonged treatment".

News Notes

Word has recently been received from Athens of the formation of the **Hellenic Orthopaedic Surgery and Traumatology Association.** The officers of the new Association are: Dr. Ath. Contargyris, Athens, President; Dr. Michael Chryssafis, Vice-President; Dr. Alex. Papadopoulos, Secretary; Dr. Alex. Hadjigeorgion, Treasurer; and Dr. Lucas Carabarbonins, Recording Secretary.

At the annual election of the **Washington Orthopaedic Club,** on May 10, the following officers were elected: Dr. Paul O'Donnell, President; Dr. Milton Cobey, Vice-President; and Dr. Everett J. Gordon, Secretary-Treasurer, all of Washington, D. C.

An interesting program was presented at the annual meeting of the **Ohio State Orthopaedic Society,** held in Columbus May 14 and 15, under the presidency of Dr. E. Harlan Wilson. The officers for the present year are: Dr. Rudolph Reich, President; Dr. Joseph Freiberg, President-Elect; and Dr. J. I. Kendrick, Secretary and Treasurer.

Dr. J. E. M. Thomson of Lincoln, Nebraska, was recently inaugurated President of the Nebraska State Medical Association. Dr. Thomson is also President of the American Association of Railway Surgeons, and is one of the teaching mission, touring Poland and Finland this summer under the auspices of the World Health Organization.

One of the highlights of the Alumni Conference of the **Hospital for Joint Diseases,** New York, held on May 24, 25, and 26, was the Sir Robert Jones Lecture, presented this year by Sir Reginald Watson-Jones. He spoke on "Death and Growth of Bone". At the three morning sessions on Orthopaedic Surgery, presided over by Leo Mayer, M.D., Samuel Kleinberg, M.D., and Harry D. Sonnenschein, M.D., interesting programs were presented. At the afternoon session on May 26, at which Dr. Mayer presided, a seminar was presented on "Herniated Disc and Other Back Lesions".

The Seventy-sixth Annual Meeting of the **American Public Health Association** will be held in Boston, November 8 to 12, 1948. This congress of professional public health workers is the largest of its kind held anywhere in the world. It will be attended by representatives from all parts of the United States, from Canada, Cuba, and Mexico, and from Latin American countries. Delegates from Europe and Asia are also expected. Meeting with the American Public Health Association will be many related organizations which select the same time and place as the Association for their annual meetings. Dr. Reginald M. Atwater is the Association's Executive Secretary, with offices at 1790 Broadway, New York 19, N. Y.

The **United States Army Medical Department** announces the availability of opportunities for advanced training and experience in the various special fields of medicine and surgery in overseas Army hospitals. These hospitals are registered with the American Medical Association, and this training may be accepted by the specialty board as part of the period usually required to be spent in limited practice and experience prior to admission for examination. Interested members of the medical profession who have completed the formal training requirements for certification in one of the special fields are eligible to apply for these positions.

The hospitals are located in Germany and Austria. These locations provide excellent facilities and equipment, a wealth of clinical material, and the services of visiting consultants who are outstanding specialists in the various fields of medical practice. In addition, opportunities will be afforded to observe the work of notable scientists and physicians in German and Austrian Universities.

The applicant may avail himself of this training for periods of one, two, or three years. Prior military service is not required.

Eligible physicians are invited to communicate with the Surgeon General, United States Army, Washington 25, D. C., for further information.

The Thirty-second Congress of the **Società Italiana di Ortopedia e Traumatologia** was held in Rome on October 25, 26, and 27, 1947, under the chairmanship of Prof. Marino-Zuco. The two principal subjects for discussion were "Treatment of Spastic Palsy" and "Rare Osteopathies". Among the speakers on the first subject were Prof. Znoli and Dr. Borellini of Genoa. Prof. Calandra of Palermo and Prof. Pennacchietti of Turin participated in the discussion. The principal speaker on the second subject was Prof. Casuccio of Bologna, who illustrated his presentation with material from the Istituto Rizzoli. Prof. Marino-Zuco and his associates also gave a preliminary report of results of the use in Italy of streptomycin in the treatment of bone and joint tuberculosis.

The thirty-third meeting of the Society will be held in October 1948, in Bologna, with Prof. Delitala as Chairman.

The International Society of Orthopaedic Surgery and Traumatology will hold its Fourth Congress in Amsterdam on September 13 to 18, with headquarters at the American Hotel. On Tuesday, September 14, the subject for discussion will be "Treatment of the Deforming Arthritides of the Hip". The discussors will be Professors Padovani (France), Zahradníček (Czechoslovakia), La Chapelle (The Netherlands), Delchef (Belgium), Wiberg (Sweden), Mathieu (France), and Smith-Petersen (U.S.A.). On Wednesday, September 15, "Occult Traumatisms of the Vertebral Column" will be discussed by Professors Nicoll (Great Britain), Böhler (Austria), Pais (Italy), Inclán (Cuba), and San Ricart (Spain). Thursday and Friday, September 16 and 17, will be devoted to papers and case presentations, and operating sessions in the hospitals of Amsterdam. On Saturday, September 18, visits will be made to the orthopaedic clinics at Rotterdam, Leiden, Nijmegen, and the University of Utrecht.

Dr. Henry W. Meyerding, President of the Congress, invites any orthopaedic surgeons from the United States who may be in Europe during that week to attend the scientific sessions and social functions of the Congress. Those surgeons who are planning to attend this Congress should notify Dr. Henry W. Meyerding, 102 Second Avenue, S. W., Rochester, Minnesota; Dr. Jean Delchef, Secretary General, Rue Montoyer 34, Bruxelles, Belgium; and Dr. J. D. Mulder, Secretary of the Congress, Vondelstraat 75, Amsterdam, Holland.

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Sixty-first Annual Meeting of The American Orthopaedic Association, under the presidency of Dr. R. I. Harris, was held at the Chateau Frontenac, Quebec City, June 3 through 6, 1948. This was also the first combined meeting of the American, British, and Canadian Orthopaedic Associations. An excellent program had been prepared by the Program Committee under the chairmanship of Dr. J. L. McDonald, and many excellent papers were presented by members of the three Associations. One of the features of the meeting was an exhibition (see page 790) of the work of Dr. Tait McKenzie, who was well known to many members of the three Associations.

The program follows:

THURSDAY, JUNE 3

Morning Session

Brief Address of Welcome, by R. I. Harris, M.B., President of The American Orthopaedic Association, to members and guests of the three Associations.

Introduction of Mr. Philip Newman, F.R.C.S., representing the Nuffield Travelling Fellows.

Aseptic Necrosis of Bone Following Trauma.
Edward L. Compere, M.D., Chicago, Illinois.

Management of the Aseptic Necrotic Head of the Femur in Adults.
Dallas B. Phemister, M.D., Chicago, Illinois.

Fractures of the Neck of the Femur Treated by Smith-Petersen Pin Plus Fibular Graft.
J. Patrick, F.R.C.S., Glasgow, Scotland.

Further Comments on Aseptic Necrosis of the Femoral Head, Sequel to Intracapsular Fractures.
W. W. Plummer, M.D., Buffalo, New York.
Discussion: H. Jackson Burrows, F.R.C.S., London, England;
Robert W. Johnson, M.D., Baltimore, Maryland;
J. Albert Key, M.D., St. Louis, Missouri;

Dallas B. Phemister, M.D.;
J. Patrick, F.R.C.S.;
W. W. Plummer, M.D.

Subtrochanteric Leg Shortening.
Lawson Thornton, M.D., Atlanta, Georgia
Discussion: Walter P. Blount, M.D., Milwaukee, Wisconsin;
J. Warren White, M.D., Greenville, South Carolina;
J. Albert Key, M.D., St. Louis, Missouri;
Juan Farill, M.D., Mexico City;
Lawson Thornton, M.D.

Noon

First Executive Sessions of the American, British, and Canadian Orthopaedic Associations.

Afternoon Session

Osteoid Osteoma: A Clinical-Pathological Study of a Series of Cases.
Malcolm Dockerty, M.D., Rochester, Minnesota (by invitation);
Ralph K. Ghormley, M.D., Rochester, Minnesota.
Discussion: T. Campbell Thompson, M.D., New York, N. Y.;
R. K. Ghormley, M.D.;
Fremont A. Chandler, M.D., Chicago, Illinois;
George E. Bennett, M.D., Baltimore, Maryland.

Arthrodesis of the Hip—Ischiofemoral Method.
H. A. Brittain, F.R.C.S., Norwich, England.
Discussion: Joseph A. Freiberg, M.D., Cincinnati, Ohio:
Wallace H. Cole, M.D., St. Paul, Minnesota;
E. S. Evans, F.R.C.S., Alton, England;
K. H. Pridie, F.R.C.S., Bristol, England;
Leo Mayer, M.D., New York, N. Y.
H. S. Coulthard, M.D., Weston, Ontario.

The Management of Incipient Epiphyseolisthesis of the Hip.
S. Kleinberg, M.D., New York, N. Y.

Slipping of the Upper Femoral Epiphysis.
Beckett Howorth, M.D., New York, N. Y.

Treatment of Slipping of the Upper Femoral Epiphysis. A Study of the Late Results in Forty-two Cases.
Clarence H. Heyman, M.D., Cleveland, Ohio.

Roentgenographic Changes in Nailed Slipped Capital Femoral Epiphysis.
Armin Klein, M.D., Boston, Massachusetts;
Robert J. Joplin, M.D., Boston, Massachusetts (by invitation);
John A. Reidy, M.D., Boston, Massachusetts (by invitation);
Joseph Hanelin, M.D., Boston, Massachusetts (by invitation).
Discussion: Philip Wilson, M.D., New York, N. Y.;
Robert J. Joplin, M.D.;
J. Albert Key, M.D., St. Louis, Missouri;
S. Kleinberg, M.D.;
Beckett Howorth, M.D.;
Clarence H. Heyman, M.D.

FRIDAY, JUNE 4

Morning Session

Osteo-Arthritis of the Hip Joint. Review of Over One Hundred Cases Treated by Arthroplasty.
Alexander Gibson, M.D., Winnipeg, Manitoba.
Discussion: Paul C. Colonna, M.D., Philadelphia, Pennsylvania;
M. N. Smith-Petersen, M.D., Boston, Massachusetts;
K. H. Pridie, F.R.C.S., Bristol, England;
Alexander Gibson, M.D.

The Etiology of Peroneal Spastic Flat-Foot.
R. I. Harris, M. B., Toronto, Ontario;
Thomas Beath, M.D., Columbia, South Carolina (by invitation).
Discussion: S. Alan S. Malkin, F.R.C.S., Nottingham, England;
Joseph S. Barr, M.D., Boston, Massachusetts;
R. I. Harris, M.B.

A Follow-up Study of Results in Fascial Arthroplastics of the Knee.
J. S. Speed, M.D., Memphis, Tennessee;
Philip C. Trout, M.D., Roanoke, Virginia (by invitation).
Arthroplasty of the Knee Joint—End Results.
J. Edouard Samson, M.D., Montreal, Quebec.
Discussion: Sir Reginald Watson-Jones, F.R.C.S., London, England;
Joseph A. Freiberg, M.D., Cincinnati, Ohio;
Mather Cleveland, M.D., New York, N. Y.;
George E. Bennett, M.D., Baltimore, Maryland;
Harold B. Boyd, M.D., Memphis, Tennessee:
J. Edouard Samson, M.D.
Greetings from the United Kingdom by S. Alan S. Malkin, F.R.C.S., President of The British Orthopaedic Association.
Changes in Elastic Adipose Tissue.
J. G. Kuhns, M.D., Boston, Massachusetts.
Discussion: A. W. Farmer, M.D., Toronto, Ontario;
J. G. Kuhns, M.D.
End Results of Physiological Blocking of Flail Joints.
Alberto Inclán, M.D., Havana, Cuba.
Discussion: Fremont A. Chandler, M.D., Chicago, Illinois;
Alberto Inclán, M.D.

Afternoon Session
Fracture-Dislocation of the Pelvis.
F. W. Holdsworth, F.R.C.S., Sheffield, England.
Discussion: H. Earle Conwell, M.D., Birmingham, Alabama.
Developmental Coxa Vara.
A. B. LeMesurier, M.D., Toronto, Ontario.
Discussion: William T. Green, M.D., Boston, Massachusetts;
J. Albert Key, M.D., St. Louis, Missouri;
Isadore Zadek, M.D., New York, N. Y.;
A. B. LeMesurier, M.D.
Treatment of Some Irreducible Congenital Dislocations of the Hip.
Juan Farill, M.D., Mexico City.
Arthrography in Congenital Dislocation of Hip.
F. C. Durbin, F.R.C.S., Exeter, England.
Discussion: H. R. McCarroll, M.D., St. Louis, Missouri;
M. N. Smith-Petersen, M.D., Boston, Massachusetts;
Paul C. Colonna, M.D., Philadelphia, Pennsylvania;
Walter P. Blount, M.D., Milwaukee, Wisconsin;
Juan Farill, M.D.;
F. C. Durbin, F.R.C.S.
Arthrodesis of the Ankle Joint.
W. E. Gallie, M.D., Toronto, Ontario.
Discussion: Alan DeForest Smith, M.D., New York, N. Y.;
Dallas B. Phemister, M.D., Chicago, Illinois;
Thomas Beath, M.D., Columbia, South Carolina;
J. Albert Key, M.D., St. Louis, Missouri;
W. E. Gallie, M.D.
Some Aspects of Metabolic Bone Diseases.
Fuller Albright, M.D., Boston, Massachusetts (by invitation).
Estrogens and Bone Formation in the Human Female.
Mary S. Sherman, M.D., Chicago, Illinois (by invitation);
C. Howard Hatcher, M.D., Chicago, Illinois.
Discussion: A. R. Shands, Jr., M.D., Wilmington, Delaware;
Fuller Albright, M.D.

SATURDAY, JUNE 5

Morning Session
Congenital Discoid Meniscus.
I. S. Smillie, F.R.C.S., Edinburgh, Scotland.
Knee-Joint Changes After Meniscectomy.
T. J. Fairbank, F.R.C.S., Reading, England.

Discussion: Joseph S. Barr, M.D., Boston, Massachusetts;
H. M. Coleman, M.D., Toronto, Ontario;
Edwin F. Cave, M.D., Boston, Massachusetts;
J. Albert Key, M.D., St. Louis, Missouri;
Philip Lewin, M.D., Chicago, Illinois;
I. S. Smillie, F.R.C.S.,
T. J. Fairbank, F.R.C.S.

Compression Arthrodesis of Knee.
John Charnley, F.R.C.S., Manchester, England
Discussion: J. Albert Key, M.D., St. Louis, Missouri;
George W. N. Eggers, M.D., Galveston, Texas;
Donald E. Starr, M.D., Vancouver, British Columbia;
John Charnley, F.R.C.S.

Treatment of Cervical Fracture and Fracture-Dislocation.
William A. Rogers, M.D., Boston, Massachusetts.

Treatment of Fracture-Dislocations of the Cervical Vertebrae by Skeletal Traction and Fusion. Results Ten Years Later
W. G. Turner, M.D., Montreal, Quebec,
William Cone, M.D., Montreal, Quebec (by invitation).
Discussion: E. A. Nicoll, F.R.C.S., Manchester, England;
Carl E. Badgley, M.D., Ann Arbor, Michigan;
Paul B. Steele, M.D., Pittsburgh, Pennsylvania;
V. H. Ellis, F.R.C.S., London, England;
William A. Rogers, M.D.;
W. G. Turner, M.D.

Greetings from Canada by J. Edouard Samson, M.D., President of The Canadian Orthopaedic Association.

Organization of an Accident Service.
W. Gissane, F.R.C.S., Birmingham, England.
Discussion: John A. Heberling, M.D., Pittsburgh, Pennsylvania.

Presidential Address.
R. I. Harris, M.B., Toronto, Ontario.

fternoon Session

A conference of teachers of orthopaedic surgery, sponsored and arranged by the Committee on Undergraduate Training in Orthopaedic Surgery of The American Orthopaedic Association.
A. Bruce Gill, M.D., *Philadelphia, Pennsylvania. Chairman, assisted by Professor George Perkins*, F.R.C.S., London, England.
Introductory Remarks.
A. Bruce Gill, M.D.
Objectives of Undergraduate Orthopaedic Teaching.
A. R. Shands, Jr., M.D., Wilmington, Delaware.
The Well-Balanced Curriculum of Undergraduate Orthopaedic Teaching.
Robert W. Johnson, Jr., M.D., Baltimore, Maryland;
William T. Green, M.D., Boston, Massachusetts.
The Use of Audio-Visual Aids in the Teaching of Orthopaedic Surgery.
Fremont A. Chandler, M.D., Chicago, Illinois;
Joseph S. Barr, M.D., Boston, Massachusetts.
The Relationship of the Division of Orthopaedic Surgery with the Division of General Surgery and Other Divisions in the Medical School and Teaching Hospital.
Carl E. Badgley, M.D., Ann Arbor, Michigan;
Don King, M.D., San Francisco, California.

SUNDAY, JUNE 6

orning Session

Surgical Approaches to the Shoulder Joint — Audio-Visual Presentation.
LeRoy C. Abbott, M.D., San Francisco, California;
John B. deC. M. Saunders, M.B., San Francisco, California (by invitation);
Helen Hagey, M.D., San Francisco, California (by invitation);
Ellis W. Jones, Jr., M.D., San Francisco, California (by invitation).

Anatomical Investigation in Lumbar-Disc Degeneration.
Sten Friberg, M.D., Stockholm, Sweden (by invitation).

Discussion: Joseph S. Barr, M.D., Boston, Massachusetts;
J. Albert Key, M.D., St. Louis, Missouri;
Sten Friberg, M.D.

The Use of External Pin Fixation in Late Compound Fractures Due to War Wounds.
E. C. Janes, M.D., Hamilton, Ontario.
Discussion: John R. Moore, M.D., Philadelphia, Pennsylvania.

Treatment of Fractures of the Shaft of the Femur.
Edward Harlan Wilson, M.D., Columbus, Ohio.
Discussion: John Charnley, F.R.C.S., Manchester, England;
K. H. Pridie, F.R.C.S., Bristol, England;
Edward Harlan Wilson, M.D.

Denervation of the Elbow Joint for Relief of Pain. Preliminary Report.
James E. Bateman, M.D., Toronto, Ontario.
Discussion: J. Albert Key, M.D., St. Louis, Missouri;
James E. Bateman, M.D.

Case Report of Pedicled Nerve Graft with Discussion on the Applicability of Procedure.
F. G. St. Clair Strange, F.R.C.S., Folkestone, England.
Discussion: James E. Bateman, M.D., Toronto, Ontario;
Paul B. Steele, M.D., Pittsburgh, Pennsylvania;
R. I. Harris, M.B., Toronto, Ontario;
F. G. St. Clair Strange, F.R.C.S.

Elephantiasis Associated with Congenital Bands in Children.
A. W. Farmer, M.D., Toronto, Ontario.
Discussion: William T. Green, M.D., Boston, Massachusetts;
A. W. Farmer, M.D.

Scoliosis Complicated with Paraplegia.
K. G. McKenzie, M.D., Toronto, Ontario (by invitation);
F. P. Dewar, M.D., Toronto, Ontario.
Discussion: Arthur Steindler, M.D., Iowa City, Iowa;
F. P. Dewar, M.D.

Noon

Final Executive Sessions of the American, British, and Canadian Orthopaedic Associations.

Ralph K. Ghormley, M.D., Rochester, Minnesota, is President of The American Orthopaedic Association for the year 1948 to 1949.

At the final Executive Session of this Association, the following officers, members of committees, and delegates were elected:

Officers

President-Elect: Robert W. Johnson, M.D., Baltimore, Maryland;
Vice-President: George W. Van Gorder, M.D., Boston, Massachusetts;
Secretary: C. Leslie Mitchell, M.D., Detroit, Michigan;
Treasurer: Frank D. Dickson, M.D., Kansas City, Missouri.

Committee Members

Membership Committee: Frederic C. Bost, M.D., San Francisco, California;
Program Committee: John R. Moore, M.D., Philadelphia, Pennsylvania;
Research Committee: W. Ward Plummer, M.D., Buffalo, New York.

Delegate to the American College of Surgeons

Philip D. Wilson, M.D., New York, N. Y.

Representatives on the American Board of Orthopaedic Surgery

T. Campbell Thompson, M.D., New York, N. Y.;
J. Warren White, M.D., Greenville, South Carolina.

The following were elected to active membership in The American Orthopaedic Association:

John R. Cobb, M.D., New York, N.Y.;
Moses Gellman, M.D., Baltimore, Maryland;
Charles Edwin Irwin, M.D., Warm Springs, Georgia;
Robert Lee Patterson, Jr., M.D., New York, N. Y.;
Charles R. Rountree, M.D., Oklahoma City, Oklahoma;
Harold A. Sofield, M.D., Chicago, Illinois;
Henry Herman Young, M.D., Rochester, Minnesota.

Book Reviews

HANDBOOK ON FRACTURES. Duncan Eve, Jr., M.D., F.A.C.S., in collaboration with Trimble Sharber, A.B., M.D. St. Louis, C. V. Mosby Company, 1947. $5.00.

This handbook on the diagnosis and treatment of fractures is one of several which have appeared within the past few years. It represents methods of handling individual fractures which the author has found most effective, and it is obvious that his experience has been broad. The teaching is didactic and dogmatic, but it does represent the experience of one man with methods which, in his hands, have proved effective. The general principles of fractures are discussed, as are the general principles and fundamentals of treatment of fractures. There are short chapters on the application of plaster, open reduction, and internal fixation of fractures; and practically all fractures are dealt with as regards manipulative treatment and external fixation.

There are many ways to treat the individual fracture, and some experienced surgeons will undoubtedly disagree with some of the methods advocated in this small book. Certain surgeons would question the value of the inlay bone graft. Others would discourage the use of local chemotherapy in wounds. The use of petrolatum gauze in wounds might be questioned by some. The use of the hanging cast is advocated for certain fractures of the shaft of the humerus.

The book is too small to give much detail in the way of end-result studies, and no statistics are presented to back up the opinions which the author advances. Therefore, one must conclude that the book is based upon the opinion of one man, working in a large industrial area, and that the methods, by and large, have proved satisfactory in his hands. The book will prove useful, particularly for the young general surgeon and the general practitioner, and can be read with benefit, along with similar books which present the treatment of fractures in a somewhat different light.

NOUVELLES TECHNIQUES DE TRAITEMENT DES FRACTURES. MÉTHODES ORTHOPÉDIQUES. RÉDUCTION DANS LES CADRES DE TRACTION. SYNTHÈSES A MINIMA: BROCHAGES, ENCLOUAGES. H. Godard et R. Michel-Béchet. (Préface du Professeur J. Leveuf.) Paris, G. Doin et C^ie^, 1948. 1,500 francs.

Entitled "new techniques", this volume is concerned with the exposition of a modified form of intramedullary pinning by Kirschner wires, the method of so-called "minimal synthesis". The authors believe that reduction by skin traction is not adequate and that reduction by open operation is not desirable. They recommend reduction by skeletal traction by means of Kirschner wire, with roentgenographic control. Maintenance of the reduction is accomplished by means of intramedullary pinning and application of plaster while traction is being maintained. For intramedullary pinning, the Kirschner wire is preferred to the Küntscher nail, because it is more pliable, of smaller diameter, and therefore less traumatizing to the medullary tissues.

The second portion of the book is devoted to a study of the osseous reactions to pinning. The authors show that intramedullary pinning stimulates intramedullary callus formation. When the pin perforates an epiphyseal line, a slight retardation of growth takes place. Because of the small diameter of the wire, this seldom exceeds 3 to 9 per cent. of the total length of the femur in experimental rats. With the passage of time, this becomes minimal, so it is concluded that the wire may be passed through the epiphyseal plates into the diaphysis without material damage.

By far the largest part of the book (more than 80 per cent.) is devoted to a study and description of the methods used in the treatment of individual fractures. The chapters on the treatment of supracondylar fractures of the humerus, fractures of the forearm bones, and fractures of the femur are particularly commendable.

Directions for undertaking the various procedures are lucidly set forth. The work is profusely illustrated with excellent roentgenograms and line drawings. As an exposition of the authors' technique, it warrants careful reading by every one interested in the meticulous treatment of fractures.

SURGICAL PATHOLOGY. Ed. 6. William Boyd, M.D.; M.R.C.P. (Edin.); F.R.C.P. (Lond.); LL.D. (Sask.); M.D. (Oslo); F.R.C.S. Philadelphia, W. B. Saunders Company, 1947. $10.00.

In this sixth edition, the author has brought his subject up to date. The surgery of today is based on pathology. There is no textbook that can be of more help to the surgeon than this one.

An entire new section has been written on the surgical pathology of the heart; it deals chiefly with congenital heart disease. The congenital defects resulting in pulmonary stenosis, patent ductus arteriosus, and coarctation of the aorta are explained, and the surgical procedures now carried out are described.

Among the other new material included in this volume are sections on tumors of the larynx, pinealoma, Bittner's milk factor in relation to breast carcinoma, avitaminosis in cancer of the mouth, the method of

diagnosis of carcinoma of the cervix by Papanicolaou vaginal smear, fibrous dysplasia of bone, inflammatory nodules of muscle in chronic arthritis, and fibrositis of the back.

Boyd has revised many sections of the previous edition. As before, he summarizes the clinical features with the pathological process, for the benefit of the reader.

Again, we wish to recommend this book to all surgeons.

Source Book of Orthopaedics. Ed. 2. Edgar M. Bick, M.A., M.D., F.A.C.S. Baltimore, The Williams and Wilkins Company, 1948. $8.00.

The new edition of this valuable book will be welcomed especially by those who have known Dr. Bick's earlier work.

The book has been entirely reset, and many chapters have been revised. In Part II, dealing with Contemporary Orthopaedic Surgery, much new material has been added,—such as the section on Reparative Osteogenesis in the chapter, "Physiology", and the new chapter, "Morphology and Genetics".

The advances in treatment of bone and joint conditions within the last ten years have made necessary the revision of many of the chapters in this Part. The sections devoted to Fractures and Bone Surgery have been greatly enlarged. New chapters have been added on Surgery of the Articulations, Special Surgery of the Hip Joint, and Surgery of the Neuromuscular Apparatus.

The reading of this new edition again impresses one with the recognition of fundamental principles by pioneers in this branch of medicine throughout the centuries. Beginning with Greek and Roman practice, the treatment of diseases of the bones and joints and of congenital and acquired deformities has constantly changed with newly acquired knowledge and the availability of newer methods and refinements of techniques. However, running through the account of the sources of our present understanding is the evidence that those who early sought to relieve the conditions which they were called upon to treat, although with fragmentary knowledge and lack of equipment and of the advantages of modern surgery, recognized the same principles which underlie present-day treatment.

Orthopaedic surgery, as we know it today, is the blending of contributions, not only from surgeons, but from many who have been known for their work in the basic sciences, general medicine, and other allied fields. This comprehensive account of its development represents a tremendous amount of study and research. It is interesting reading and a valuable reference book.

Osteophthisis Pelvis et Femorum. Zugleich ein Beitrag zur Frage der spontanen Rückbildung maligner Tumoren. (Bd. 1, Weiner Beiträge zur Pathologie und pathologischen Anatomie.) Dr. Gottfried Hartmann. Wien, Wilhelm Maudrich; New York, Grune and Stratton, 1947. $5.00.

The title implies complete disappearance of the bony structures of the pelvis and of both femora. The author describes in detail the clinical, roentgenographic, and autopsy findings of a most unusual case. A woman, forty-nine years old, was admitted to the hospital in September 1941, with chief complaints of anorexia, dyspnoea, and cardiac and epigastric distress; no hematemesis had occurred. The clinical examination revealed a fairly well nourished patient, moving around on crutches. The heart was enlarged. The lungs were free and clear. There were no palpable masses in the abdomen. The liver and spleen were not enlarged. The pelvis showed no bone resistance. Roentgenographic study revealed complete absence of the bony structures of the pelvic girdle and the femora; the appearance of the gastro-intestinal tract suggested a neoplastic invasion of the lower half of the stomach; no obstruction was noted. General anasarca and ascites developed, and the patient died about two months after admission.

The story of this case begins with the first examination in 1908, when the patient was sixteen years old. She was then treated by Professor Lorenz for tuberculous coxitis, following a fall. The first roentgenograms, in 1910, showed complete absorption of the left half of the pelvis and of the femoral neck and head, except for the left iliac bone. The left leg was eight centimeters shorter than the right. This condition was progressive, so that in 1913 the patient was unable to use her right leg. There was no pain. Roentgenographic study in 1919 (when the patient was twenty-eight years old) disclosed complete absorption of the entire pelvic girdle, lower lumbar vertebrae, and femora. Professor Kienböck presented this case before the Medical Society and reported it in the literature as echinococcus disease of the bone. Except for the bone changes, the patient was clinically well. She married and a healthy infant was delivered by Caesarean section in 1924. Three years later, the patient had another section at term; the infant was normal. Following the second section, the tubes were ligated.

A summary of the autopsy findings was as follows: (1) scirrhous, linitis plastica type of carcinoma of the entire stomach and of the lower portion of the esophagus; (2) carcinomatosis of the peritoneum and of the retroperitoneal glands; (3) hypostatic pneumonia; (4) verrucous endocarditis of the mitral valve; (5) oedema of the brain; (6) chronic cystopyelonephritis; (7) abscess of the gluteal muscles on the left side; (8) osteophthisis of the bones of the pelvis and both femora, etiology undetermined; and (9) secondary anaemia.

Detailed histological studies of the specimens of the bones and of the stomach revealed a lymphangiitic

type of scirrhous carcinoma, resembling a linitis plastica. No ulcers were found. Study of the bones showed replacement of the bony structures by connective tissue, with islands of tumor cells and occasional calcium residua. Many of the vessels showed neoplastic emboli. Some areas of the femur suggested bone regeneration and an attempt at fibrous healing or replacement of the neoplastic metastatic lesions. The author attempts to explain the bone metastases as a single lymphogenous spread to the bones, the original gastric lesion having been small. The condition was kept in check by some endocrine factors (puberty and pregnancies). The growth of the metastases in the bones produced alkalosis and calcium ionization which, in turn, kept the original lesion localized until it spread rapidly in the fifth decade (climacteric). The interplay of endocrine and metabolic factors, in Hartmann's opinion, produced this unusual result.

THE ASEPTIC TREATMENT OF WOUNDS. Carl W. Walter, A.B., M.D. New York, The Macmillan Company, 1948. $9.00.

"The aseptic treatment of the wound in the operating room is the culmination of so much daily thought and effort on the part of those to whom the responsibility for its details has been relegated that most surgeons think of asepsis only as the use of rubber gloves and a few sterile drapes." In this sentence, Dr. Walter outlines the scope and theme of his book, which is one of the Macmillan Surgical Monographs, edited by the late Elliott C. Cutler.

The book contains 372 pages and 21 chapters and can be divided into the following sections:

1. *The Development of the Concept of Asepsis:* Here is an excellent chronological review of the evolution of asepsis; it is graphically outlined with pertinent information, and suffixed with references.

2. *Chemical Destruction of Bacteria:* The market today is flooded with many kinds of chemical germicides. Dr. Walter gives a very good evaluation of the commonly used germicides and a list of those which cannot be depended upon. The new synthetic phenol compound, "G-11", is described. When added to liquid soap: "Two minutes' scrubbing with the mixture [liquid soap and 2 per cent. G-11] lowers the resident count more than twenty minutes' scrubbing with ordinary toilet soap".

3. *Physical Destruction of Bacteria* (mechanical processes, heat, and steam): Dr. Walter is one of the first to emphasize the importance of the "chain of asepsis" and to point out the many possibilities of "leaks" in this chain. Every method of heat and steam sterilization is illustrated and explained. Emphasis is laid on the importance of understanding the mechanical equipment in the sterilizing room, knowing that the equipment functions properly and that it is being constantly inspected and maintained. "Leaks" in the chain of asepsis may and do occur in the sterilizing room. Excellent illustrations demonstrate the preparation of surgical kits, dressings, and drapes. The technique of sterilization is discussed.

4. *Operating-Room Technique:* This section is particularly good for teaching. Representative procedures in the operating room are covered, step by step, with many clear sketches. Surgeons are reminded again of the relative inefficiency of the surgical mask, and convincing figures are given to show the increase in contamination which occurs when loud talking, coughing, or forceful expiration is indulged in at the operating table.

5. *Central Supply:* The total plan of the central supply room, its technique, and functions are carefully and thoroughly outlined.

In the total picture of aseptic treatment of wounds, more emphasis may have been given to wound physiology and the tremendous part that untraumatized and vital tissue play in the "aseptic" treatment of wounds. There are a few very minor points in operating-room technique that may be controversial, but this does not take away from the tremendous value of Dr. Walter's work.

This monograph is a distinct contribution to surgical teaching; it is timely, complete, accurate, excellently illustrated, and clearly presented. It goes far beyond its expressed purpose as a text for medical-school courses in surgical teaching, and should be read by the busy surgeon, the house staff, the operating-room supervisor, and the hospital engineer.

SKELETAL TUBERCULOSIS. Vicente Sanchís-Olmos, M.D. (Translated from the Spanish by John G. Kuhns, M.D.) Baltimore, The Williams and Wilkins Company, 1948. $5.00.

This book represents an extensive study of the problem of skeletal tuberculosis. It is divided into two parts. The first part deals with the pathogenesis, pathological changes associated with the disease, etiological factors, and basic considerations in diagnosis, prognosis, and treatment. The second part, under the heading of "Special Subjects", considers individually the various joints and bone structures in which the disease may be manifested.

In the first part, much of the discussion is based on theory rather than on proved scientific facts. A vast working knowledge of the medical literature, both European and American, is indicated. The references represent principally material written by European surgeons, giving the average American reader an insight into their line of reasoning which he has not heretofore enjoyed.

The second part, dealing individually with the various anatomical areas, represents a repetitious résumé

of material which could be condensed without loss of value. Under each of these areas, the pathology, roent genographic appearance, symptomatology, differential diagnosis, and prognosis are discussed in detail. Thi entails a repetition of material from one part to the next, and a repetition of material previously covere under the general discussion in Part I. The treatment of the various lesions is covered only in generalities If this is to be considered as a complete text or reference book dealing with skeletal tuberculosis, it seems rea sonable that a short paragraph, outlining the steps of the actual operative procedures useful in each type o lesion, might be included. A resident surgeon, preparing to perform his first arthrodesis of a tuberculous hi cannot turn to this book for help. This decreases its value as reference material.

This book is published under the date of 1948; yet, as is true in so many instances, it is out of date befor it can be published, since recent important developments are not included. The possible value of streptomyci in the therapeutic management of this disease is not even mentioned. This drug apparently has no effect o the destructive process itself and, in the light of our present knowledge at least, fails to alter the status of th bone or joint lesion. Its value in the management of secondary soft-tissue manifestations, however, cannot b questioned. No treatise dealing with skeletal tuberculosis can be regarded as modern without consideratio of the use of this drug.

The purpose of the publication is stated to be "what is new or little known on the subject of tuberculosi of the bone". It accomplishes this purpose, although the "new" in many instances is represented by theor rather than fact. It will be of great value from an academic standpoint as a reference book for the student o skeletal tuberculosis. From a purely practical standpoint, it will be of little value to the practitioner o orthopaedic surgery.

Disability Evaluation Principles of Treatment of Compensable Injuries. Ed. 4. Earl D. McBride B.S., M.D., F.A.C.S. Philadelphia, J. B. Lippincott Company, 1948. $12 00

Previous editions of this work have placed it in an authoritative position as a manual for the prope evaluation of disability. Insurance companies and State Accident Commissions use it as a guide and sourc of information. It is a tremendous accomplishment, and the reviewer was impressed by the great amount o work necessary to produce this concise, well organized, definitive treatise.

As Dr. McBride states: "To appreciate the effects of deformity and to pass judgment on disability a practical analysis must be made of the altered anatomic form and the functional effect of the mechanica alterations".

The chapter, "The Doctor as an Expert Witness", should be read by every practitioner who is calle upon to testify in disability controversies. An insert of thirty-eight pages details the "Author's Composite Schedule of Approximate Evaluation for Partial Permanent Disability". His method is based on function,— in other words, what can the patient do. He analyzes these factors.

McBride also presents the principles of treatment of disabling injuries. It might be well to delete this portion of the book entirely. The work on disability rating is outstanding and authoritative, in itself a subject difficult to master. The addition of treatment to this encyclopedic volume detracts from, rather than adds to, its value.

The Foot and Ankle. Their Injuries, Diseases, Deformities and Disabilities. Ed. 3. Philip Lewin, M.D., F.A.C.S. Philadelphia, Lea and Febiger, 1947. $11.00.

The third edition of Dr. Lewin's book is a complete revision of his previous work. The experience of the author in World War II, as well as his study of methods used in other military hospitals, is the basis for many of the sections added in this edition. They are representative of the newer concepts of etiology, the advance in research in chemotherapy, and improved surgical techniques.

Many illustrations have been added, most of them reproduced from surgical journals, featuring the newer methods of treatment presented by various authors in recent years.

The excellent bibliography is valuable for the reader who wishes to locate individual articles on these subjects and to pursue his studies on foot conditions. Dr. Lewin states that "with very few exceptions, no reference is included that has not been read by the author".

Criticism may be made of the author's method of presentation. This may be illustrated by the chapter on Talipes Equinovarus. After some general statements concerning the etiology, the author presents his own method. This section on "Lewin's technic" does not include a description of the method of manipulative correction used.

In the discussion of club-foot, the Kite method is depicted incorrectly. Application of a foot cast with molding, then a leg cast, and finally maintenance of maximum correction with a plaster bandage around the foot and over the knee are not demonstrated in the pictures or text. Likewise, the pre-correction line drawing of a roentgenogram fails to show the abnormal relationship of talus and calcaneus.

"J. W. White glues the soles of the feet together with compound tincture of benzoin or other adherent material and binds the feet together with a resilient bandage for three or four months." This sentence, under

the heading of Talipes Equinovarus, is misleading, because White uses this type of therapy for congenital pronation or calcaneovalgus deformities,—the antithesis of equinovarus deformities

The reviewer believes that there is overdramatization in the author's statement that the time to treat club-foot is when the child is six minutes of age rather than six weeks The consensus today is in favor of early correction, but from two to six weeks of age is early, and delay until the child has left the nursery of the hospital has many advantages for the patient, the mother, and the physician

Various methods of therapy, non-operative and operative, are also discussed in this chapter, but without consideration of indications, preference by the author, or end results This chapter is encyclopedic, but of little assistance to the relatively inexperienced physician; to choose a method of therapy, the physician must have had experience and training Of all the common abnormalities of the foot which are present in infancy and childhood, congenital equinovarus deformity is probably the one requiring the most exact and definite therapy It is for this reason that this chapter has been chosen for criticism

In the discussion of flat feet, the etiology and pathology are well reviewed Again, however, the various non-operative and operative methods of therapy are described, including a number of antiquated procedures, but an evaluation of each method is not given, and no indications or suggestions as to choice of procedures are mentioned

The advertisement from the publisher describes this book as "almost encyclopedic in scope" This is true. The orthopaedic surgeon who wishes to refer to a specific therapeutic procedure will probably find it described On the other hand, the less experienced physician may be confused by the quantity of facts, figures, and illustrations

British Surgical Practice Volume II Edited by Sir Ernest Rock Carling, F R C S, F R C P, and J. Paterson Ross, M S, F R C S London, Butterworth and Company, Ltd, 60 shillings (25 pounds for the set), St Louis, C V Mosby Company, 1948 $15 00 ($125 00 for the set).

The second in the series of eight volumes, plus an index, which make up *British Surgical Practice*, is now available The subject matter is arranged alphabetically, so that Volume I began with Abdominal Emergencies and ended with the Autonomic Nervous System, Volume II begins with Backache and concludes with Bursae

In general, a different group of authors have contributed to the second volume, but the arrangement of subject matter remains essentially as in Volume I, and includes for most conditions a discussion of surgical anatomy, etiology, pathology, differential diagnosis, operative technique, and results of treatment Excellent illustrations are included Several chapters on bones and bone-grafting appear in Volume II, written by B H Burns, Peter Walton, R W Ellis, Donald Hunter, H J Seddon, and Sir Harry Platt

This outstanding set of books is being published simultaneously in Great Britain and the United States The first volume appeared at the end of 1947 The remaining volumes are scheduled to appear during 1948 and 1949

The 1947 Year Book of Orthopedics and Traumatic Surgery Edited by Edward L Compere, M D, F A C S Chicago, The Year Book Publishers, Inc, 1948 $3 75

The 1947 Year Book of Orthopedics and Traumatic Surgery is the first volume under the new title and by the new Editor Dr Compere has done well the difficult task of gleaning from the literature important articles appearing during the year, which come within the scope of orthopaedic surgery, including trauma to the spine and extremities, and weaving the abstracts of these articles into a consecutive account of progress, which makes a readable book

This handy reference book is invaluable for the busy surgeon who may not have read the original articles in the many journals represented, but who wishes to know of the developments in this field of surgery It should have a place in the library of every surgeon called upon to deal with lesions of the bones and joints

The Medical Annual A Year Book of Treatment and Practitioner's Index. Editors. Sir Henry Tidy, K B E, M A, M D (Oxon), F R C P, and A Rendle Short, M D, B S, B Sc, F R C S Bristol England, John Wright and Sons Ltd, 1947

A group of forty-five outstanding physicians and surgeons have contributed to the 1947 Medical Annual, now in its sixty-fifth year of publication The main portion of the book contains a review of the work done in medicine and surgery in England during the year Following this is a section devoted to new pharmaceutical preparations, new appliances, and a classified list of the new books of the year.

The Annual contains a variety of subject matter, arranged alphabetically and in concise form. New advances made during the year have received special attention

In this edition, social medicine is included for the first time, in a discussion by F A E Crew, Professor of Public Health and Social Medicine of the University of Edinburgh After a broad survey of the subject,

Professor Crew concludes: "We as a people are now resolved to build out of the wreckage of war a new and better external world in which we may biologically and socially flourish. All the vast programmes of planning now being considered and unleashed are but the expression of this resolve. The medical profession is heavily involved in these events. Expanding social medicine is one of the newer instruments that medicine has fashioned so that it may play its proper and prominent part in this grand adventure."

THERAPEUTIC EXERCISE. F. H. Ewerhardt, M.D., and Gertrude F. Riddle, B.S., R.N., R.P.T. Philadelphia, Lea and Febiger, 1947. $2.50.

This volume is written to provide students of physiotherapy and occupational therapy with a background in the field of therapeutic exercises. The preliminary chapters deal with the physiology and anatomy of joints, muscles, and peripheral nerves in relation to exercise. The remainder of the volume is devoted to specific applications of exercise in medicine.

The text can be recommended for its brief and concise coverage of a neglected field of therapeutics. The lack of adequate illustrations, however, detracts from its usefulness as a text for students. The failure to include a reference to progressive-resistance exercises (DeLorme), which have received much prominence in recent years, is an omission too serious to be overlooked. In general, however, the volume will be of value to those in the field of physical medicine, who desire a guide for the teaching of therapeutic exercise.

PRINCIPLES OF OCCUPATIONAL THERAPY. Edited by Helen S. Willard, B.A., O.T.R., and Clare S. Spackman, B.S., M.S., O.T.R. Philadelphia, J. B. Lippincott Company, 1947. $4.50.

This book fills a great need in the field of occupational therapy, as textbooks such as this have been badly needed. The subject of occupational therapy is covered in a general manner.

The book will be of value for students of occupational therapy. It will also be useful to doctors who are interested in this field, and to occupational therapists who are changing from one branch of this work to another. For example, one working in the field of tuberculosis or psychiatry would find the chapter on physical injuries of value.

The chapters on army, navy, and veterans' programs, however, have no logical place in such a textbook. Unfortunately, the book is sadly lacking in illustrations.

In general, this work is to be recommended to students and to those unfamiliar with the value of occupational therapy.

KINESIOLOGY. LABORATORY MANUAL. Leon G. Kranz, M.S. St. Louis, The C. V. Mosby Company, 1948. $2.75.

Visual aids are extremely important in teaching the actions of muscles. This loose-leaf manual adequately illustrates the action of all the principal muscles, with the exception of those of the hands and feet, by line drawings of individual muscles and their skeletal attachments. Verbal descriptions are in outline form, except for analysis of more complex movements. Although it is intended primarily for students of physical education or physical therapy, this should prove a convenient reference for many doctors and medical students. It would be made more valuable by the addition of drawings of the nerve supply and by an index.

AKUTE ÄUSSERE PROZESSE. DIE PHYSIOLOGIE DER CHIRURGISCHEN UND KONSERVATIVEN THERAPIE. Dr. Josef Riese. *Wien, Wilhelm Maudrich, 1948.*

This unusual title, "acute superficial processes", is used by Riese to describe the inflammatory lesions which are easily reached. The physiological pathology is described, and from this the author attempts to explain therapeutic procedures. The discussion of treatment frequently becomes abstract and philosophical; it reminds one of medical papers written ten to fifteen years ago.

While the author mentions both sulfonamides and penicillin, he apparently has had very little opportunity to use either of them. The book will be of little interest to surgeons in this country, who use antibiotics probably too freely, without thought of the natural resistance of the host or of simple methods of fighting infection. For such doctors, the book is of historical value only. In the absence of antibiotics, however, this book is a mine of valuable information for combating purulent infections. It discusses not only the older proved procedures, but a number of newer ones as well, which were born out of necessity when sulfonamides and penicillin were not available.

VOL. 30-A, NO. 4 OCTOBER 1948

The Journal of
Bone and Joint Surgery

American Volume

THE FUTURE OF ORTHOPAEDIC SURGERY *

BY ROBERT I. HARRIS, M.B., TORONTO, ONTARIO, CANADA

On this occasion, historic because the Orthopaedic Associations of Great Britain and of Canada are meeting jointly with us, we may well pause to consider the background of our growth, which, from small beginnings, has led us steadily onward to this unique landmark in our special field of surgery. Nor can we fail to give some thought to the future and what it may hold for us in increased knowledge of orthopaedic problems and improved techniques for the mastery of disease.

In the years which have elapsed since its founding, The American Orthopaedic Association has traveled an interesting pathway of development. The original fourteen surgeons who met in the home of Dr. Shaffer in New York "to discuss the formation of The American Orthopaedic Association" could have had no conception of the magnitude and importance of the project they were launching. Indeed there was no unanimity among the founding fathers; two voted against the motion, and two abstained from voting. Yet the majority succeeded in establishing a scientific organization greater than they could have thought possible. They would have rejoiced, could they have witnessed its progress through the years; and I like to think that they would have been especially proud to share in this Meeting with two other orthopaedic associations whose existence, in some measure, is due to the stimulus, example, and interest of the Association they founded sixty-one years ago.

From the outset our Association manifested healthy vigor. Its founding members were men of intelligence, energy, and foresight. Even in the earliest meetings, the papers they presented displayed originality and interest. Important new contributions to knowledge are sprinkled through every issue of the Transactions. Vigorous discussion was the rule. In 1901, for instance, when Clarence L. Starr of Toronto recorded his experience in 'The Treatment of Abscesses in Tubercular Bone Lesions", his paper of four and a half pages was followed by nine pages of discussion.

The Association came into being at an opportune moment in the history of surgery. Lister's technique of antiseptic surgery had proved its merit, and aseptic surgery had made its first appearance. It was now possible to operate upon patients with the confidence that the wound would heal and no harm would result to the patient. Operations of election became feasible, because they were safe. This revolutionary advance opened a field of immense possibilities to those who were concerned with the treatment of deformities. No longer was the surgeon limited to slow and feeble correction by braces and splints. If he was skillful and bold, he might obtain an instant and perfect correction by operation upon the deformed extremity. Orthopaedic surgery, as we know it, could not have come into existence except for the safeguards of Lister's discovery. Safety in operating made possible the development of a great new field of elective operations, peculiarly suited to the problems of orthopaedic surgery.

It was in this atmosphere that the new Association was founded and spent its formative years. It is not surprising, therefore, that its meetings were vigorous and stimulating.

* President's Address, delivered at the Joint Meeting of The American Orthopaedic Association, The British Orthopaedic Association, and The Canadian Orthopaedic Association, Quebec, Canada, June 5, 1948.

In the first sixteen years, during which the papers read at the annual meetings of the Association were recorded in the Transactions of The American Orthopaedic Association, there were many contributions of historic importance. Not unnaturally, the new opportunities in the field of operative surgery aroused the interest of the orthopaedic surgeon. New and ingenious operative procedures occupied his attention and enabled him with increasing certainty to correct deformity and to cure disease.

In 1895, when the Association was eight years old, Roentgen discovered the x-ray and gave to orthopaedic surgeons a new agent for diagnosis and for assessing the results of treatment. There is singularly little discussion of this epoch-making discovery in the annual proceedings of the Association, but gradually papers appeared, which were illustrated with reproductions of roentgenograms, often in the form of tracings. The use of this diagnostic agent grew slowly. Doubtless the crudity of the early roentgenograms made it difficult to appreciate the vast potentialities of x-ray technique in the study of bone disease.

During the years of its existence, the influence which the Association has exerted has been great and has steadily increased, until today it molds the thinking and practice, not only of orthopaedic surgeons, but of the world of medicine at large.

It is a far cry from 1894, when A. M. Phelps of New York in his Presidential Address discussed the transition from "*orthopedy*" (the treatment of deformities by manipulations, braces, and splints) to "*orthopedic surgery*" (the operative treatment of deformities by surgeons who devoted themselves to this field). It was a vigorous fighting speech, defying the general surgeons to equal the skill and interest of the orthopaedic surgeons. He defended the development of specialism and pointed to the advances achieved by the young specialties of ophthalmology and gynecology. He was so bold as to claim for orthopaedic surgery not merely fractures of the neck of the femur, but all fractures and also dislocations. ". . . . many members of this Association include in their work the treatment of fractures of the neck of the femur, and with them I fully agree. But why fractures of the neck of the femur and not all fractures? If all fractures are to be treated, why not dislocation?" He even claimed hernia for the orthopaedic surgeon, for the reason that it was he who could most skillfully carry out treatment by truss. "Hernia unquestionably should be classified as an orthopedic subject. It is as important and as difficult to adjust a support to remedy a hernia as a splint to hip-joint disease, and frequently, by mechanical means, herniae are cured."

Phelps surveyed the future with far-sighted optimism. What he said in 1894 must have seemed visionary to his audience and irritating to his rivals, the general surgeons. Yet, most that he dreamed of has been accomplished and much besides.

At the early annual meetings, before the turn of the Century, the presentations were concerned with congenital deformities, tuberculosis of bones and joints, recurring dislocations, new designs for splints and braces, deformities due to bad posture, slipping of the upper femoral epiphysis, rachitic deformities, foot deformities, and other foot disablements, operative techniques (such as osteoclasis), scoliosis, typhoid spine; and there were occasional papers on infantile paralysis and on fractures. It is singular that fracture problems were so seldom discussed at the early meetings of this Association. It can only indicate how long a time was necessary to transform Phelps's "orthopedist" to an "orthopedic surgeon" in the modern sense of the term.

In the first three decades of this Century, orthopaedic surgery advanced apace. The technique of antiseptic surgery had been completely replaced by that of aseptic surgery. Operative surgery rapidly evolved new and improved principles which made possible and safe the exploration of every part of the body. This was a challenge to the craftsmanship of the surgeon to master more and more complex technical procedures, in order to achieve greater and greater results. To none had this more appeal than to the orthopaedic surgeon. His response was a great outpouring of new and modified operations by which the results of treatment were greatly improved.

Meantime, additions to knowledge were accumulating, and many of them were germaine to orthopaedic surgery. In 1912, Macewen published his monograph on "The Growth of Bone", which reopened for modern times the scientific study of bone as a body tissue, previously advanced by Hunter. Macewen's challenging statement that periosteum was merely a "limiting membrane" and had no osteogenic powers focused attention upon this tissue, with which orthopaedic surgeons are daily concerned. The outcome of these studies laid the foundations of modern knowledge of bone structure and provided the background necessary for successful operations for the treatment of bone disease.

In 1911, Hibbs reported his first spine fusion, and within a few months Albee reported his first spine bone-graft. In 1913, Gallie and Robertson commenced their studies on the "Repair of Bone". These and other contributions on the same problems provided exact knowledge of the reaction of bone to injury, the repair of fractures, and the fate of transplanted bone, and made possible the development of improved operative procedures. The great period of operative orthopaedics was inaugurated, and with it the modern era of orthopaedic surgery commenced.

Some facility had barely been acquired in these skills when the First World War broke out. Its problems in the management of acute trauma to the extremities and in the rehabilitation of grossly damaged limbs were a challenge to orthopaedic surgeons. The demand for their skill and experience was great, and their response greatly advanced the position of orthopaedic surgery. That they successfully met this challenge was due in large part to the good fortune of wise leadership by strong personalities.

Following the First War, the casualties of industry and the toll of motor traffic continued the demand for the skill of orthopaedic surgeons. Finally came the climax of the Second World War, with its renewed demand for the services of those skilled in the knowledge and management of injuries and infections of bone and joints and prepared to devote to this exacting field the time and effort necessary to achieve success. Orthopaedic surgery has now become of age. There is an essential role for it to play in the world of surgery, and this Association has played no small part in guiding it to maturity.

Such great progress in the past sixty-one years invites speculation upon what the future may hold for us. Our generation, and to a great extent that of our preceptors before us, have been concerned with mastering the techniques of operative orthopaedics. The opportunities provided by safety in surgery invited the development of new and improved operations, which yielded prompt rewards in better results from treatment. It has been a great and stimulating period, appealing to the sense of craftsmanship possessed by every surgeon. That period is ending, and we stand now at the threshold of a new era, more stirring and with even greater possibilities than the old. It is worth our while for a few moments to examine the future.

Of great significance is the changed and still changing relationship of orthopaedic surgery to the general body of surgery. No longer is it a small field, separated from general surgery and cultivated by a group of men desiring to limit themselves to this smaller interest. Expanding knowledge in the fields of biochemistry, physiology, endocrinology, and histology have made all fields of surgical treatment broader and more complex. More is now demanded of the surgeon than clinical skill in diagnosis, knowledge of gross pathology, and technical dexterity. He must have a sound working knowledge of the basic sciences and of the physiology, biochemistry, endocrinology, histology, and anatomy of the organs he undertakes to treat, in addition to the gross and microscopic pathology of their diseases. Such extensive mastery of all the factors bearing upon the problems he undertakes to treat by surgery limits the scope of his activities. It has become increasingly difficult and finally impossible for one individual to be master in all fields of surgery. From choice or circumstance he deals with problems limited to one field. General surgery, in the former sense of the term, no longer exists. The general surgeon of today has become in fact a specialist in visceral surgery. What once, with justice, was called general surgery has be-

come separated into departments which deal with related problems. Some of these depar ments are large and some are small. The larger bear a relationship of equality to one ai other; none subservient to another in importance or responsibility, though there has yet t be wide recognition of this fact. In this new picture, the position of orthopaedic surgery secure, because it has an essential part to play. If it has any problem, it is to encompa adequately the extent of its field.

The distribution of activities now imposed upon surgery by the necessity of limitin the work of the surgeon to that which he is physically capable of accomplishing, affect most the academic surgeon. He is responsible for many things in addition to the operativ treatment of disease. We look to him to organize and conduct the research which wi produce new knowledge; to assess intelligently new contributions in related fields, particu larly in the basic sciences; and to transmit to others the knowledge and skill he himself ha acquired. Such multiple responsibilities demand much of his time and energy. It is he wh feels first and most strongly the need for the division of surgery into fields of specia interest.

Although it is inevitable that surgery be divided into convenient subdepartments there is something to regret in this necessity, because of the danger of isolation of the various fields of surgery from one another. Such separation must be avoided at all costs The effective measure to combat it is the development of the interests which are common to all fields of surgery. These are research, the basic sciences, and teaching. If every department of surgery has responsibilities which compel it to keep abreast of progress in the basic sciences, to initiate and direct research, and to share in the training of doctors, there will be a common meeting ground for all departments, with a sharing of knowledge and interests which will prevent isolation. Moreover, too great subdivision of surgery must be avoided. To divide surgery into smaller and smaller specialties is certain to narrow interest and to lead to isolation. If we are to retain vitality, the necessary subdivision of surgery must be into broad groups of related interests.

Recognition of the new position which orthopaedic surgery occupies in relation to the rest of surgery makes clear the responsibility which rests upon us as orthopaedic surgeons. We are entitled to claim orthopaedic problems for ourselves only so long as we can deal with them better than can other surgeons. We must, therefore, acquire such skill and experience as will ensure that our surgical treatment is of the highest quality; and, in addition, we must hold ourselves responsible for the acquisition of new knowledge concerned with the field of orthopaedic surgery. To accomplish this, we must familiarize ourselves with the new developments in related fields of surgery and in all the fundamental sciences which have any bearing upon orthopaedic surgery, and utilize this as a basis for research. To claim for ourselves a special field of surgery, or to have it allocated to us, carries with it an equivalent responsibility. Our only title to the field must be greater skill in treatment, greater ability to advance knowledge in this field, and better claim to transmit to succeeding generations of students the knowledge which has been accumulated.

Opportunities to advance knowledge in the field of orthopaedic surgery are greater at this moment than at any previous time. Advancement of orthopaedic surgery by improvements in the technique of operative procedures has passed its zenith, but opportunities for such broader progress lie before us, by the utilization of new knowledge from the fields of the fundamental sciences, biochemistry, physiology, endocrinology, and histology. The rapidly expanding knowledge in these fields is likely to yield great and stimulating results when applied to orthopaedic surgery. Few tissues of the body today offer so fruitful a field for investigation into the fundamentals of their structure and function as do bones, joints, ligaments, and connective tissues, and this in spite of all the previous work which has been accomplished in this field.

A brief survey will indicate how great are the opportunities for the development of new knowledge by the exploration of our own field of interest with facts available from the fundamental sciences.

Histology

The early work of Gallie and Robertson and of Phemister laid the foundation of our present knowledge of bone repair and the fate of bone transplants. It still is the solid basis of fact for the application of the histological characteristics of bone to clinical problems. But in the interval, much new knowledge of tissue structure has evolved; a great deal of this is concerned with intercellular substances and throws new light upon the structure of bone, so much of which consists of specialized intercellular substance. It should be emphasized that bone is not static; it is a living mobile tissue, responsive to many influences and stresses.

Biochemistry

Since bones represent the largest store of calcium in the body, the chemistry of this element is a matter of obvious importance to the orthopaedic surgeon. The metabolism of calcium has been the subject of study from the earliest days of biochemistry, but most of this has been concerned with calcium balance. Robison's isolation of phosphatase in 1924 made the first contribution to our knowledge of the local mechanisms whereby calcium is deposited or removed from the skeleton. The extensive studies of Albright have contributed a great deal to our knowledge of calcium changes in bone, both generalized and local. How useful it would be to know the mechanism which would lay down new bone where and when we need it.

There are some biochemical aspects of bone which at the moment we regard as curiosities. They may be important clues to details of bone metabolism as yet unsolved. An example is the deposition of fluorine in the bones of patients exposed to abnormal amounts of this element.

Physiology, Including Endocrinology

A vast amount of work has been expended upon the study of the action of endocrines. The knowledge gained is encyclopaedic in scope. Nevertheless, much remains to be solved, especially in respect to the effect of endocrines upon bones and joints. Enough is known to make us appreciate the vastly important part they play in bone growth and in bone formation. Giants or dwarfs result from disturbances of the normal interplay of endocrines upon the epiphyseal lines. Profound osteoporosis of varying types follows certain disturbances of endocrine function. As yet, we know little of the local mechanisms whereby these changes are effected or of the subsidiary changes which result from minor deviations of endocrine balance.

During our professional lifetime we have seen the disappearance of rickets, which in 1900 provided an enormous number of deformities for the orthopaedic surgeon to correct by means of Grattan's osteoclast. Its elimination was due to the discovery of the existence of vitamin D and of its function. There may be similar less obvious vitamin influences upon bone. The problem is still inadequately explored.

The physiology of muscle fibers is open to much interesting investigation, designed to throw light upon many problems related to orthopaedic surgery. A great mass of information is already available, but more knowledge is still needed. The work of DeLorme has shown some empirical factors which influence muscle strength and size, on which we have no scientific information.

Anatomy—Relationship of Structure to Function

The bones and joints with which the orthopaedic surgeon is concerned, especially those of the lower extremity, are unique in this respect: Disturbed function often results from changes in structure, caused by deviation from normal standards or changes acquired after birth, following disease or deformity. The rigid structure of bone preserves its shape and affords us an opportunity to study alterations in shape and structure. Such studies,

for the most part, have been concerned exclusively with structural changes, and have not attempted to explore the possible relationship of these to disturbed function, which indeed they could not do, since they have no means of knowing the function during life of the material in their anatomical museums. By combined clinical, roentgenographic, and anatomical investigations, it is possible to study the relationship of structural changes to impaired function. Standardized roentgenograms can be related to structural changes seen in anatomical specimens. This procedure can then be used to conduct a survey of the anatomy of the skeleton on living patients, from which the relationship between structure and function can be assessed. Many foot disabilities (flat-foot,claw-foot, hallux valgus) result directly from deviations from the normal standard of structure of the skeleton.

There is also a place for mass roentgenographic surveys to determine the incidence and nature of bone diseases and anomalies. We recently have utilized the miniature films of a mass chest survey to determine the incidence of scoliosis. Suitable roentgenographic surveys would be valuable to eliminate low-back disabilities in army recruits, as well as for the study of certain foot problems, as for instance hallux valgus.

Pathology

There is need for the development by pathologists of a special interest in the problems of bone surgery. Skill in this field is difficult to achieve. The clinical pathologist has many demands upon his time and energy, especially in these days of exfoliative cytology. The tissue is difficult to prepare, and the technique is time-consuming. Often special stains and preparations are necessary. The quality of the sections may vary greatly. But above all, there is the fact that the problems in bone-cell pathology are peculiar. They require the attention of a pathologist who has a special interest in this field.

From these remarks it will be evident that the future development of orthopaedic surgery will derive from fields other than those concerned with operative techniques. We are likely to obtain great increases in our knowledge of the intimate structure and function of bone and cartilage and the connective tissues by new knowledge derived from the fundamental sciences. This provides us with a new approach to our problems, likely to be fruitful of results. We shall gain more precise knowledge of diseases of the locomotor system than we have ever before possessed.

To make the fullest use of the opportunity which lies before us, we must keep ourselves familiar with progress in the fundamental sciences, and this is no easy task. Nevertheless, it must be recognized that the responsibility of a teaching medical school is to provide contacts between the fundamental sciences and the clinical departments, and to encourage research by the departments of surgery, which in orthopaedic surgery will explore the nature of the tissues with which we are concerned.

This Association is in a position to assist the early appraisal of those new developments in the fundamental sciences which are of possible value in orthopaedic surgery. Most orthopaedic surgeons in the English-speaking world read *The Journal of Bone and Joint Surgery*. It would serve a most useful purpose if the *Journal* could establish an Abstract Section, broad enough in its scope to include a summary of every article in the world of science which might be of value to orthopaedic surgeons, in addition to those articles which deal directly with orthopaedic surgery. Some attempt at this is made in certain other reviews, but in none is there complete coverage. Moreover, the best are in surgical journals, not readily available to all orthopaedic surgeons. The place for such a comprehensive review of the literature is in *The Journal of Bone and Joint Surgery;* its scope should include the publications in the fields of bacteriology, pathology, biochemistry, physiology, endocrinology, anatomy, histology, and perhaps even certain engineering and metallurgical journals.

The change in our approach to the problems in orthopaedic surgery will necessarily

(Continued on page 847)

BONE LESIONS IN EOSINOPHILIC GRANULOMA, HAND-SCHÜLLER-CHRISTIAN DISEASE, AND LETTERER-SIWE DISEASE

BY IGNACIO PONSETI, M.D., IOWA CITY, IOWA

From the Department of Orthopaedic Surgery, State University of Iowa Hospitals, Iowa City

Eight cases seen in the University of Iowa Hospitals have been selected to illustrate the clinical, roentgenographic, and histological characteristics of bone lesions occurring in eosinophilic granuloma, Hand-Schuller-Christian disease, and Letterer-Siwe disease[1]. Although the cause of these diseases is still very obscure, studies made during the past decade have established that they probably represent forms of the same pathological process[2, 4, 5]. This series of cases is presented mainly to corroborate this modern trend of thought.

Although the eosinophilic granuloma is probably a localized lesion in bone, the granulomatous lesions of the Hand-Schüller-Christian and Letterer-Siwe syndromes are widespread, and many organs are involved. Bone lesions are very frequent, but are not always present. In the case described by Letterer in 1924, for example, no bone lesions were present, and only a moderate increase in reticulocytes was found in the marrow. At least one case similar to this was studied on the Pediatric Service of the Iowa University Hospitals, but it will not be reported here. Only the cases with manifest bone lesions are included in this series.

Two cases with solitary eosinophilic granuloma of bone are presented.

CASE 1. D. L. S., a girl, two and one-half years old, had always been in good health. She was brought to the Hospital on August 7, 1945, because the mother, while combing the patient's hair, had noticed a

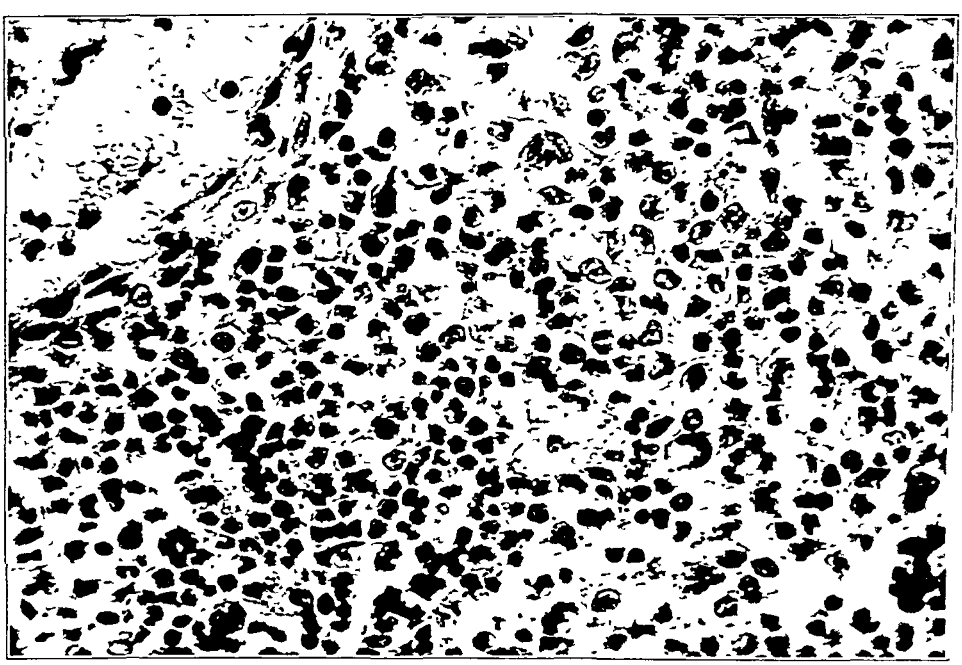


FIG. 1

Case 1. Eosinophilic granuloma of the skull, formed by large mononuclear cells with granular protoplasm and a great number of eosinophils

slowly growing soft mass over the right frontal area. This mass was first noted five weeks prior to admission, was tender to touch, and had slightly increased in size during the previous two weeks. The patient's general condition was good, except that she tired easily.

The child was well developed and well nourished and the only abnormal finding, on physical examina tion, was a bone defect in the right frontal region, six by four centimeters in size. The scalp over this defec was bulging slightly and was moderately tender, but there was no redness or increase in local heat. A fev submental lymph nodes were palpable. The urine contained a slight trace of albumin and many bacteria The red-blood-cell count was 3,700,000; the white-blood-cell count, 5,150. Blood cholesterol was normal The roentgenograms showed a round, well-outlined defect, three centi meters in diameter, in the right aspect of the frontal bone.

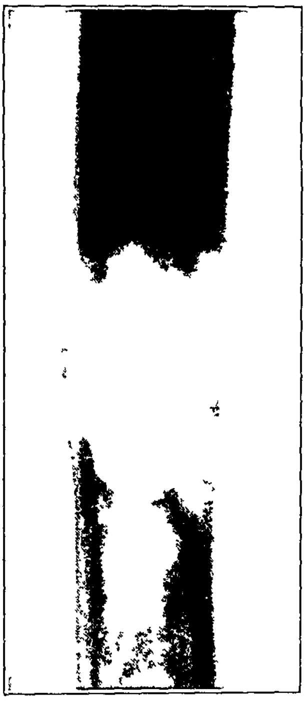


FIG. 2-A

At biopsy, the bone defect was found to be filled with a grayish-pinl tissue, which was adherent to the dura. The portion of the dura to whicl the tissue was adherent was excised. The brain appeared to be normal, anc the surface of the dura in contact with it was smooth. The tumor tissu was carefully dissected from the scalp and then was removed. The wounc was closed in layers.

The histological sections showed a very cellular tissue, containin large cells with one or two large oval or kidney-shaped nuclei. The proto plasm of most of these cells was granular or finely vacuolated. Mitoti figures were very scarce. A great number of eosinophils were seen scatterec throughout (Fig. 1).

No postoperative roentgenotherapy was given. The patient was seer two years later and at that time was asymptomatic. The skull defect wa still present, but it had decreased slightly in size. The bone surrounding the defect had become sclerotic.

CASE 2. A. H., a male, forty-six years old, had been in good health al his life. He came to the Hospital on January 8, 1942, stating that one yeai prior to admission, he had been kicked in the left tibia by a steer. He hac

Fig. 2-A: Case 2. Roentgenogram of the left femoral shaft, showing an irregular area of bone destruction.

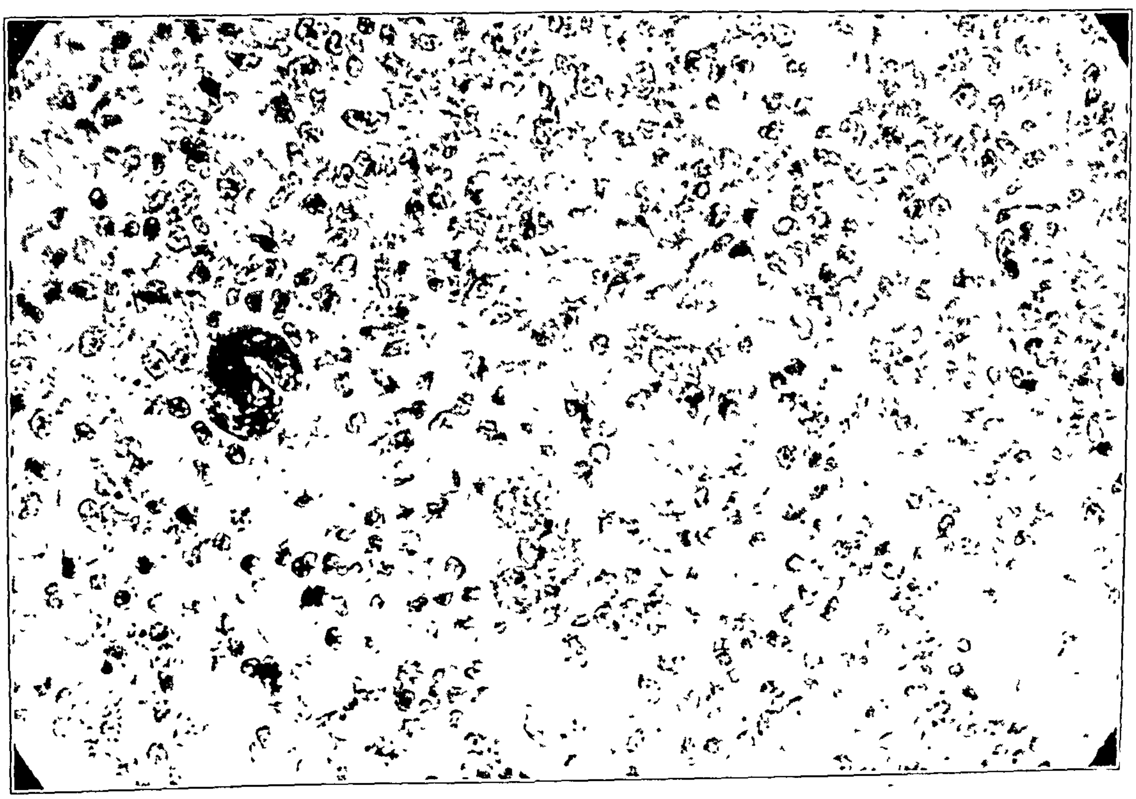


FIG. 2-B

Photomicrograph of the tissue obtained at biopsy, showing large mononuclear cells, eosinophils, and large giant cells.

had no immediate discomfort, but three weeks later the left knee had become swollen. Aspiration had been done several times, and bloody fluid had been obtained. The knee was painful and caused the patient to limp. The pain had increased slowly until two weeks prior to admission, when it became excruciating, and the man was unable to walk without crutches. There was no history of weight loss, chills, or fever at any time.

On physical examination a slight, non-tender, soft-tissue infiltration was found in the lateral aspect of the left mid-thigh. The knee appeared normal, except for slight pain on complete extension. There was atrophy of the left thigh of about one inch, and the strength of the quadriceps was diminished. Blood counts and all other laboratory examinations were normal. The roentgenograms showed osteochondritis dissecans in both knees, and an irregular area of destruction at the middle third of the left femoral shaft. The cortex was thin and eroded anteriorly. A minimal amount of periosteal new bone surrounded the edges of the lesion (Fig. 2-A).

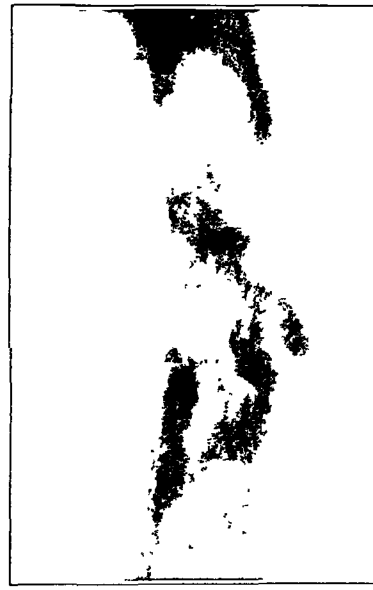


FIG. 2-C

Roentgenogram of the left femur, taken one year later than Fig. 2-A.

At biopsy on January 18, 1942, the anterior cortex was broken through. The large bone defect was filled with a dark hemorrhagic and friable semigelatinous tissue. On microscopic examination, this tissue appeared to be relatively avascular and granulomatous in nature, and it was composed of viable masses of large mononuclear cells, eosinophils, large giant cells, fibroblasts, and small mononuclear cells (Fig. 2-B). There were hemosiderin-laden large mononuclear phagocytes and widespread evidence of old and recent hemorrhage. The mononuclear cells had a light-staining cytoplasm, which was occasionally dimly vacuolated, and chromatin-rich nuclei. Eosinophils were present in great numbers and showed a tendency to be in clumps. Many appeared to be young, but no abnormal forms were seen. There were many large giant cells which varied from 30 to 60 micra in diameter, with one large oval or cleft nucleus, rich in chromatin. Multinucleated forms could be seen, having up to ten nuclei. Mitotic figures were fairly frequent, and some atypical forms were detected. There were areas of moderate fibrosis, in which the mononuclear cells appeared smaller, and there were fewer giant and eosinophilic cells. Lymphocytes were more abundant at the periphery of the process, and a few irregular masses of newly formed bone were found in the region of the partially destroyed periosteum. Cultures and guinea-pig inoculations were negative. Mouse-brain inoculations and dog-bone inoculations were also negative. A diagnosis of eosinophilic granuloma was made. Ten days after the biopsy, the granuloma was partially curetted, and a tibial graft was implanted in the destroyed area of the femur. A hip spica was applied.

Four months after the curettage, the old lesion was still visible in the roentgenograms, but it was smaller, and no active bone destruction could be seen. The bone grafts were still visible. For the next four months the patient had no complaints and began partial weight-bearing on crutches.

On January 5, 1943, almost one year after the operation, the patient returned, complaining of a somewhat painful soft-tissue mass over the site of the bone lesion. This had gradually developed during the preceding two months. The roentgenograms showed that the area of bone destruction had greatly increased in size, but a roentgenogram of the lung fields was negative. It was assumed by some members of the Hospital Staff that the lesion was malignant. The area was then irradiated with 1,200 roentgens to each of four portals. During hospitalization the patient sustained a pathological fracture of the involved femur (Fig. 2-C).

On February 12, 1943, one month after roentgenotherapy, there was no appreciable decrease in the size of the soft-tissue mass. A mid-thigh amputation was then thought to be the treatment of choice. The middle third of the femur was found to be honeycombed and filled with soft hemorrhagic, friable tissue. A few small fragments of bone were found, and these were thought to represent the residua of the previously implanted tibial grafts.There was no evidence of invasion in the surrounding muscle.

Microscopic sections revealed very extensive areas of necrosis. There were many large mononuclear cells and scattered large giant cells, as were seen at biopsy one year previously. Eosinophils, which were so predominant at the time of the biopsy, were not present in these sections. Mitotic figures were scarce, and no foam cells were seen. The muscle tissue was not invaded. The bone sections revealed considerable sclerosis. There was no convincing evidence of malignancy.

Postoperative recovery was uneventful. Five years later, there was no clinical or roentgenographic evidence of metastases. The man had gained forty pounds since the operation and wore a prosthesis with no discomfort.

Case 1 represents a typical example of eosinophilic granuloma of bone. The patient was a young child. The lesion was slightly tender and located in the frontal bone. In the

roentgenograms it appeared well outlined with clear-cut, regular borders. The microscopic examination showed a granulomatous tissue, composed of large mononuclear cells and many eosinophils. The lesion was completely resected and has not recurred.

The clinical course and microscopic picture of the tumor in the second case were suggestive of malignancy. The patient was forty-six years of age, which is considerably above the average age when eosinophilic granuloma occurs. (Versiani, Figueiró, and Junqueira described a case of a fifty-year-old woman with diabetes insipidus, who had a lesion in the femoral shaft similar to the one described in this patient.) The roentgenograms showed an area of bone destruction with irregular contours which threatened to destroy the whole thickness of the femoral shaft for a length of six centimeters. The biopsy revealed a very unusual and malignant-appearing tissue, formed by large mononuclear cells, eosinophils, and enormous giant cells, with one or several deeply stained and very large nuclei. The lesion recurred after curettage and produced extensive bone destruction, although it did not infiltrate into the soft tissue. The leg was amputated one year after biopsy. The eosinophils, which had been so predominant at the time of biopsy, were no longer seen in the granulomatous tissue of the amputated specimen. In spite of the amputation having been performed only a few centimeters above the site of the lesion, there was no evidence of local recurrence or metastasis five years later.

CASE 3. W. B., a man, thirty-four years old, was first seen in this Clinic on May 15, 1940. He gave a history of dull aching pain in the anterior aspect of the right knee, which had begun in June 1939, and had lasted for three months. There was no history of trauma. He had had no further symptoms in the knee until March 1940, when severe pain in both knees developed. Onset had been spontaneous and rapid, but at no time had there been swelling or limitation of motion. This episode had lasted for five days and he had then been free of symptoms until April 17, 1940. At that time he had had swelling of the left cervical lymph nodes and a few days later swelling of the right cervical nodes. Two weeks later the left ankle had become swollen and painful. The day before admission, the fourth finger of the right hand had become markedly swollen and painful on motion. The patient had lost fifteen pounds during the two months prior to admission.

On examination, the cervical nodes were found to be swollen, hard, and freely movable under the skin. The body temperature was normal. The fourth finger of the right hand was swollen and painful on motion. The anterior aspect of the right ankle joint and both tibial tubercles were slightly tender. The skin was normal. Examination of the heart and lungs was negative. The spleen and liver were not palpable. Neurological and genito-urinary examinations were negative.

Blood analysis showed:

Red blood cells	5,200,000
White blood cells	12,000
Polymorphonuclear neutrophils	75 per cent.
Eosinophils	5 per cent.
Lymphocytes	18 per cent.
Monocytes	2 per cent.

Blood cholesterol and total lipids were not increased. Sedimentation rate was normal. Blood examinations were normal for serum calcium, phosphorus, and phosphatase. Serological examinations were negative.

The roentgenographic examination showed a round area of rarefaction in the proximal end of the middle phalanx of the right fourth finger, measuring six millimeters in diameter, with no evidence of bone sclerosis around it. There was a round area of rarefaction located in the right tibial tubercle, measuring two centimeters in diameter, with no surrounding bone sclerosis. Similar, but poorly defined, areas of rarefaction were seen in the upper lateral quadrant of the right patella and in the lower end of the left tibia. Examination of the skull was negative.

Two cervical lymph nodes were removed for biopsy. The connective tissue surrounding the lymph nodes was very rich in histiocytes, many of which had crescent-shaped nuclei (Fig. 3-B). Between the germinal centers many histiocytes were also seen. A block of bone from the upper anterior portion of the right tibia was removed for biopsy. When this had been sectioned, a cavity was encountered, which occupied the whole thickness of the bone cortex. This cavity was filled with soft, yellow, friable tissue. On microscopic examination, this tissue was found to contain closely packed lymphocytes, plasma cells, and some large cells, with clear nuclei lying in a fine connective-tissue reticulum. In a few locations there were some large, pale, vesicular foam cells. Abundant numbers of eosinophils were seen in some areas. A large amount of fat was found in the foam cells (Fig. 3-A). Smear and cultures were negative.

Two months after the biopsy, the patient returned, complaining of pain in both knees, both ankles, and an increase of the pain in the third and fourth fingers of the right hand. The lymph nodes of the neck were

still hard, enlarged, and freely movable The lateral malleolus on the left and the medial malleolus on the right were very tender The tibial tubercle on the left was very tender, as well as the one on the right, previ-

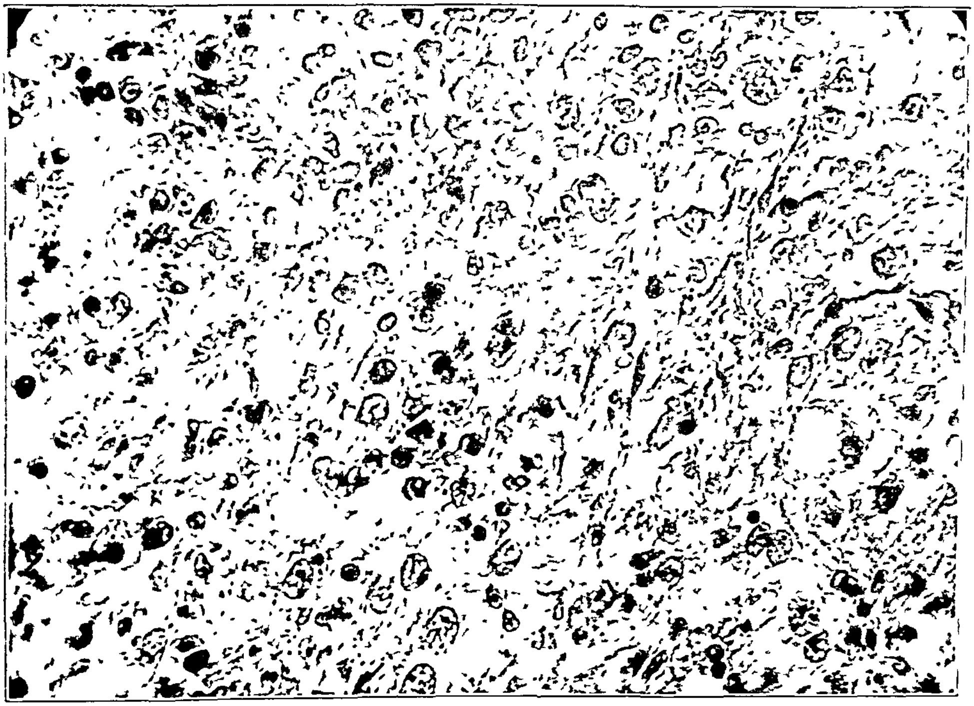


FIG 3-A

Case 3 High-power photomicrograph of tissue found in a bone cavity in the upper anterior cortex of the right tibia Large mononuclear cells with granular protoplasm are abundant.

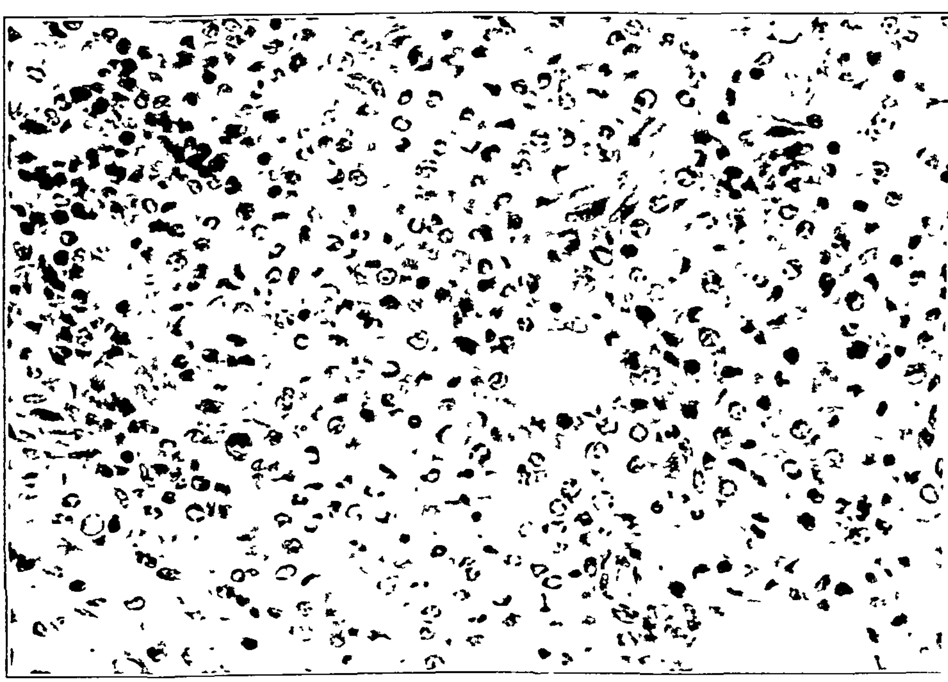


FIG 3-B

Photomicrograph of tissue surrounding a cervical lymph node Many of the mononuclear cells have crescent-shaped nuclei.

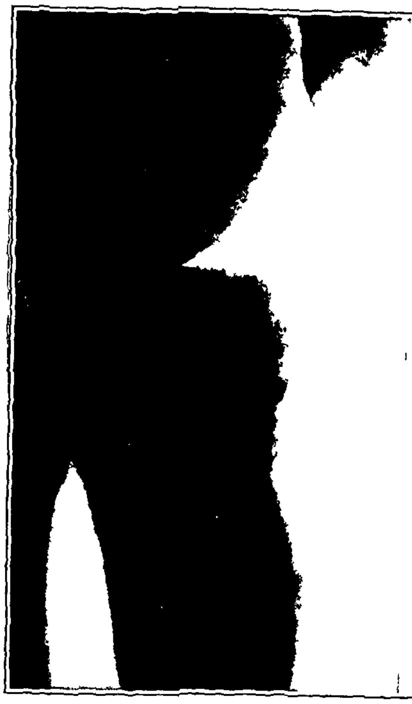


FIG. 3-C

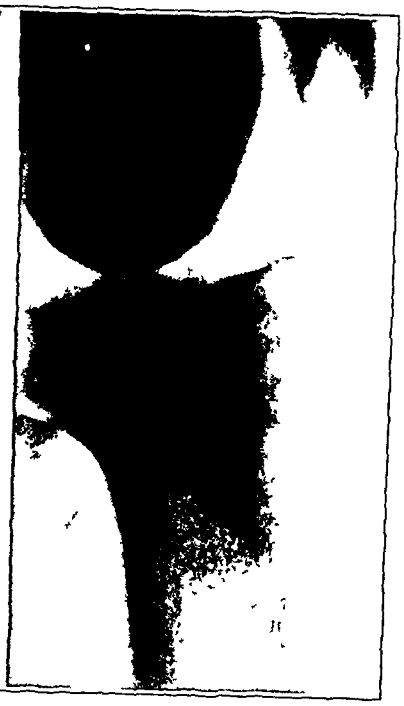


FIG. 3-D

FIG. 3-E

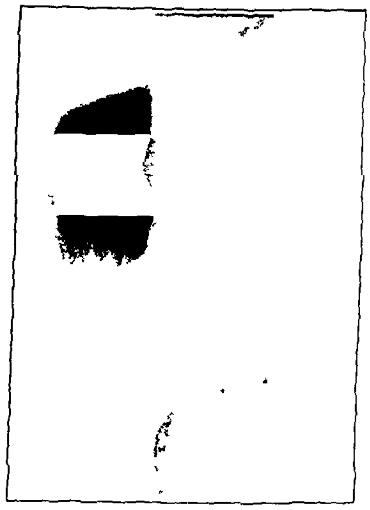


FIG. 3-F

FIG. 3-G FIG. 3-H

Fig. 3-C: Roentgenogram of upper portion of left tibia, showing an irregular area of rarefaction in the tibial tubercle. Roentgenotherapy was given to this area.

Fig. 3-D: Roentgenogram of the left tibia, four years later, shows that the lesion is nearly healed.

Fig. 3-E: Roentgenogram of right patella, showing extensive areas of rarefaction.

Fig. 3-F: The right patella appeared normal in the roentgenogram taken five years later, although no treatment had been given over this area.

Fig. 3-G: Roentgenogram shows areas of rarefaction in middle phalanx of ring finger and proximal phalanx and metacarpal of middle finger.

Fig. 3-H: Three years later, the areas of rarefaction had nearly disappeared.

ously operated upon. There was no swelling, redness, or limitation of motion in the ankles or knees. The roentgenograms showed areas of rarefaction in the left lateral malleolus, the right medial malleolus, and the left tibial tubercle (Fig. 3-C). Two areas of rarefaction were also evident in the right patella, which had been only dimly seen on the roentgenograms taken on previous examination (Fig. 3-E). The roentgenogram of the right hand showed an increase in the size of the rarefied area in the middle phalanx of the fourth finger, and new areas of rarefaction appeared in the proximal end of the first phalanx and the distal end of the metacarpal of the third finger of the same hand (Fig. 3-G). The roentgenograms of the skull were negative.

The patient was given roentgenotherapy,—600 roentgens to the tibial tubercles and ankles, and 400 roentgens to the involved bones of the right hand The ankles and the right hand became quite painful during the treatment. The lesion of the right patella was not treated and was used as a control The lymph nodes of the left cervical region were also irradiated, those on the right were not

A few weeks after the roentgenotherapy, the pain in the ankles, left knee, and right hand had all but disappeared. However, the untreated knee continued to be painful Roentgenograms of the involved areas failed to show any changes that could be attributed to the treatment As a matter of fact, the lesions in the right hand appeared somewhat larger. The patient had gained weight

Similar roentgenotherapy was given to the same areas three months later This was followed by complete relief of the symptoms, except for some pain in the untreated right knee The roentgenograms showed no appreciable changes in the areas of bone destruction It was noted that, although only the left cervical lymph nodes had been irradiated, the nodes on both sides had regressed to an equal degree, so the treatment may have had nothing to do with the improvement

When seen six months later, the pain in the right knee had disappeared The man then returned to work, and has been continuously employed since that time He has been free from symptoms

Each year the roentgenograms have demonstrated a slow, but continued regression in all rarefied areas. When the patient was last seen in November 1946, all of the lesions appeared healed, except for a small radiolucent area in the distal portion of the middle metacarpal bone (Figs 3-D, 3-F, and 3-H). However, a small cystic area had appeared in the distal end of the right ulna

This patient had multiple bone involvement, with pain of spontaneous and rapid onset, and marked swelling of the affected right fourth finger. The cervical lymph nodes were also involved. The clinical history, together with the increased number of polymorphonuclear neutrophils in the blood, suggested a low-grade chronic osteomyelitis. The patient had no fever, however; there was no local heat in the affected areas; the sedimentation rate was normal; and the roentgenograms showed that the areas of bone destruction were well outlined and surrounded by normal-appearing bone. The microscopic examination of the material obtained from one of these areas of bone destruction revealed granulomatous tissue in which there were a large number of histiocytes, containing a great deal of lipoid material, and a few eosinophils in some areas. There were also some chronic inflammatory cells, but very few polymorphonuclear neutrophils. Two of the swollen cervical lymph nodes, examined under the microscope, also showed concentrations of histiocytes between the germinal centers and in the tissue surrounding the lymph nodes. Smears, cultures, and animal inoculations were negative.

The diagnosis of chronic osteomyelitis could not be substantiated. The case did not appear to be one of a typical multiple eosinophilic granuloma, because the tissue taken from the tibia resembled a lipogranuloma rather than an eosinophilic granuloma, and the cervical lymph nodes were involved. A diagnosis of Hand-Schuller-Christian disease would not have been proper, because areas of bone destruction in the skull, exophthalmos, and diabetes insipidus had not appeared during the seven years we followed this patient. The case probably represents an intermediary form between the multiple eosinophilic granuloma and Hand-Schüller-Christian disease.

The roentgenotherapy given to the involved areas relieved the pain in a few weeks. The lesion in the right patella, which was not treated, continued being painful for several months. However, the roentgenograms taken every three months failed to show any changes in the areas of bone destruction which could be attributed to the benefit of roentgenotherapy. With or without treatment, the bone lesions and the swollen lymph nodes regressed slowly. The roentgenograms demonstrated a progressive and almost complete reossification of all the involved areas, without signs of sclerosis in the surrounding bone.

Case 4. M. McC., a sixteen-year-old white male, had multiple eosinophilic granulomata, enlargement of the spleen and lymph nodes, pulmonary infiltration, and diabetes insipidus.

This patient was first seen in this Clinic in March 1939, complaining of generalized fatigue, painful inflamed gums, and a weight loss of twenty-three pounds during the preceding five months The gums had been inflamed for eight months and six loose teeth had been extracted in August 1938.*

* This patient had been carefully studied by L. E. January, M.D., of the Department of Internal Medicine.

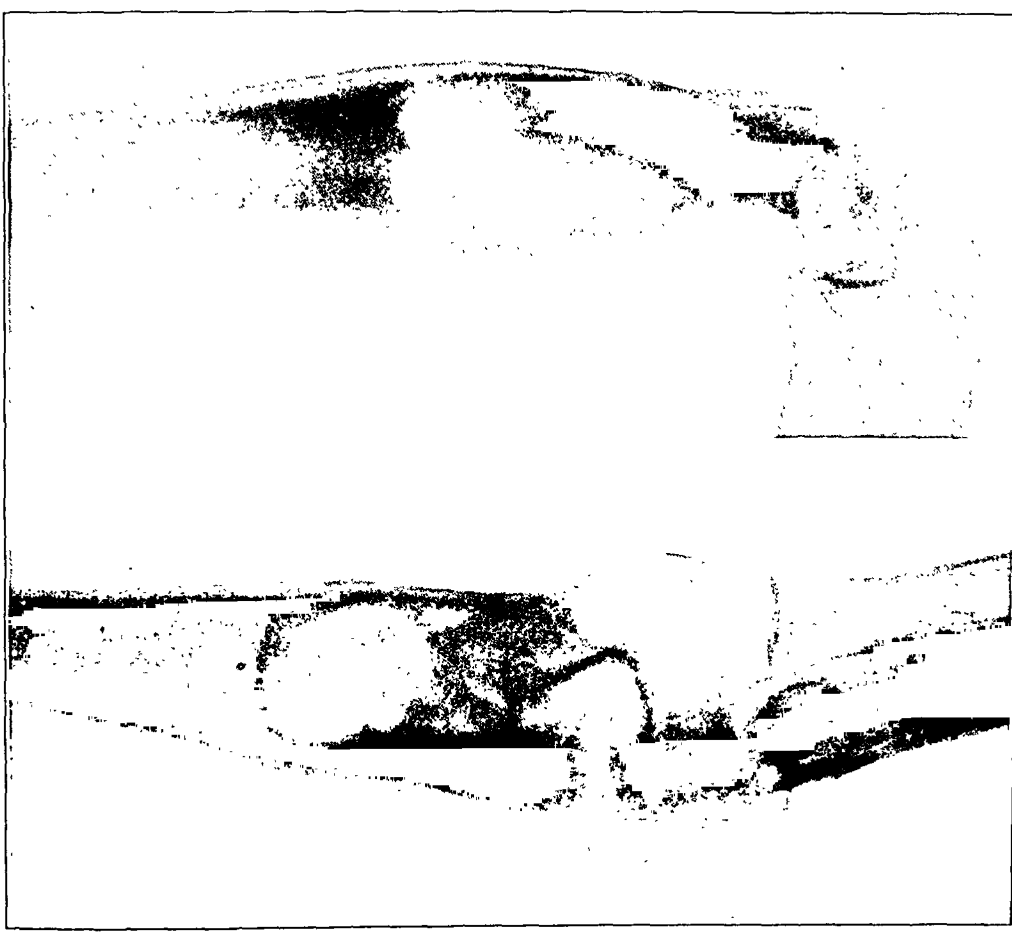


Fig. 4-A

Fig. 4-B

Figs. 4-A and 4-B: Case 4. Roentgenograms of the left elbow, taken in September 1939, show a well-outlined loculated, cystic area in the lower end of the humerus. The cortex is expanded and there is overlying periosteal new-bone formation.

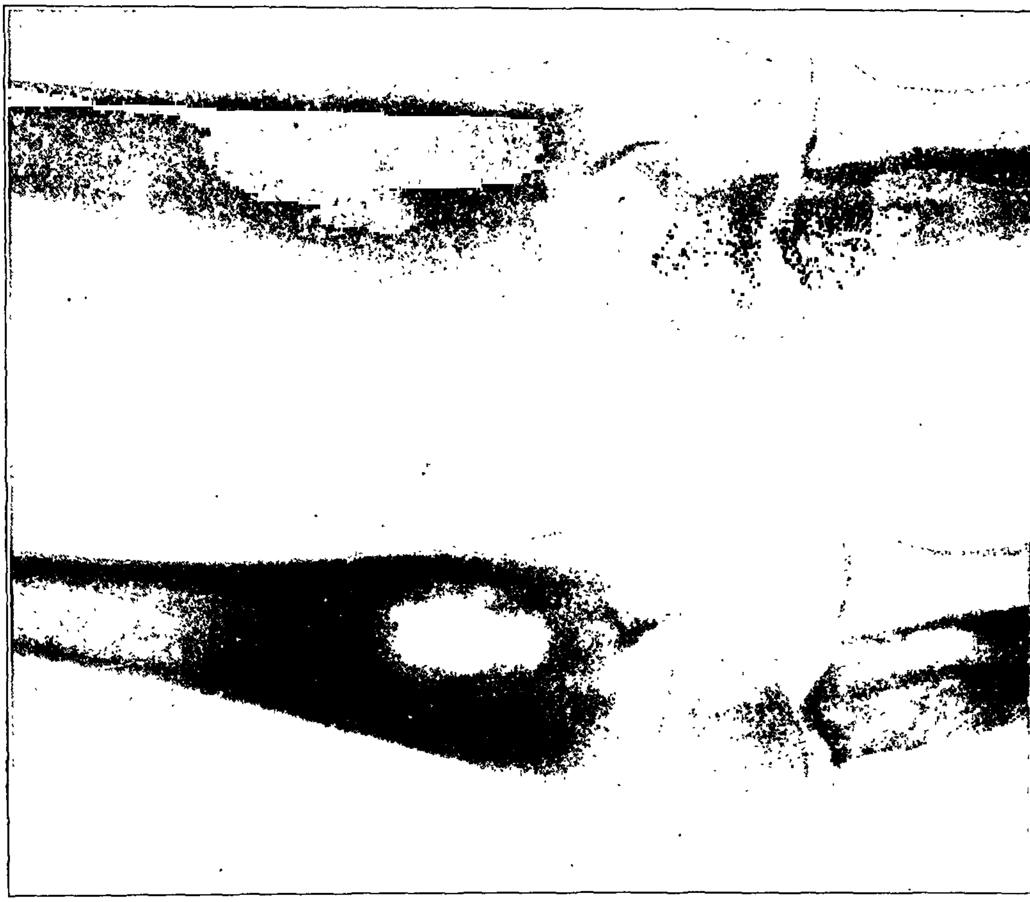


Fig. 4-C

Fig. 4-D

Fig. 4-C: Roentgenogram, taken one and one-half years after curettage and filling of the cavity with bone chips, shows recurrence of the lesion. Roentgenotherapy was then given.

Fig. 4-D: Roentgenogram, taken two years after roentgenotherapy, shows healing of the lesion.

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Examination revealed a thin, pale, poorly nourished patient, who weighed eighty-two pounds. The gums were inflamed and had receded from the teeth; pus could be expressed from beneath the gums. The remaining teeth were carious. Axillary and inguinal lymph nodes were palpable bilaterally. Examination of the lungs and heart was negative. The tuberculin test was negative. The spleen was slightly enlarged.

Blood examination showed:

Red blood cells	5,300,000
White blood cells	8,850
Polymorphonuclear neutrophils	55 per cent.
Eosinophils	3 per cent.
Lymphocytes	33 per cent.
Basophils	2 per cent.
Monocytes	4 per cent.
Blast cells	3 per cent.

The patient's urine output was considerably increased (average of 6,000 cubic centimeters in twenty-four hours; the highest was 8,000 cubic centimeters) The specific gravity was 1.002. The polyuria responded to pituitrin (0.3 cubic centimeter given hypodermically every eight hours).

The roentgenograms of the lungs showed a fine infiltration of the major portions of both upper lung fields. The roentgenograms of the skull were negative

In September 1939, the patient returned, complaining of pain in the left elbow following a minor injury. The lower end of the humerus appeared somewhat expanded and was slightly tender. Pronation and supination were normal, but the flexion-extension range of the elbow was limited to 155 to 70 degrees of motion. The roentgenograms showed a sharply outlined, lobulated, cystic area in the lower end of the humerus. The cortex was thin and expanded, and there was overlying periosteal new-bone formation (Figs. 4-A and 4-B). The roentgenograms of the other bones, including the skull, were negative. There was still an infiltration of the apices of both lungs, but this was not so prominent as in the roentgenograms taken on previous admission. Blood calcium, phosphorus, phosphatase, and cholesterol were within normal limits. Calcium excretion in the urine was slightly elevated.

The cystic lesion of the lower end of the humerus was explored. The cavity was filled with gelatinous, soft, friable tissue, and the walls were lined with a grayish, fibrous tissue. The underlying bone was very dense and hard. This tissue was completely removed by curettage and the cavity was filled with bone chips from the tibia. The histological sections showed a very cellular tissue, containing sheets of large cells with abundant, pale cytoplasm and round, pale, eccentrically placed vesicular nuclei. Few mitotic figures were present. A few very large foam cells, with small dark nuclei, were seen clustered throughout the tissue. Many areas showed a great mixture of large mononuclear cells, lymphocytes, and an extremely large number of eosinophils (Fig. 4-E).

Roentgenograms taken on successive months showed that the cystic area of the humerus, which had been operated upon, was becoming smaller. However, the roentgenograms taken ten months after surgery demonstrated the reappearance of small new areas of rarefaction in the same region. Treatment of 600 roentgen units was then given to the lower end of the left humerus.

In May 1940, following a severe upper-respiratory infection, the patient complained of a draining right ear. The roentgenograms revealed destruction of the base of the temporal pyramid which appeared to be one large loculated cavity, measuring 4.5 by 4 centimeters in size (Fig. 4-F). An exploratory mastoidectomy was performed and, after removal of a thin, bony shell, pale, yellowish-gray, soft, lobulated tissue was easily scraped out with a curette. The histological examination of this tissue showed an eosinophilic granuloma of identical structure as the lesion found previously in the lower end of the left humerus.

Roentgenograms of the pelvis showed a cystic lesion in the superior ramus of the pubis and several small cystic areas in the pubic bone. Three treatments of 200 roentgens each were given on successive days to the right mastoid and to the right side of the pelvis. The remaining loose teeth were extracted; and a few weeks later the gingivitis and stomatitis had disappeared. The diabetes insipidus was being controlled by the injection of one cubic centimeter of pitressin tannate in oil, every three to five days.

In May 1941, the patient returned for consultation; he complained of marked pain in the left elbow, which appeared slightly swollen. The roentgenograms showed a new large area of bone destruction in the lower end of the humerus where the old lesion had been (Figs. 4-C and 4-D). Treatment of 800 roentgens was given to the left elbow, and the pain was relieved a few days after the treatment. The lesions in the pelvic bones were smaller.

In July 1941, a sharp pain suddenly developed in the right ear. There was some diminution of hearing; the auricle was very tender. The right canal was almost completely occluded by a very painful swelling of the floor and roof of the external auditory canal. The roentgenograms showed that the defect in the right mastoid had increased in size. Treatment of 600 roentgens, in three divided doses, was given to the right ear. A few days after the treatment the pain had disappeared.

In September 1943, the patient began to have pain in the left thigh; walked with a limp; had no appetite; and was losing weight.

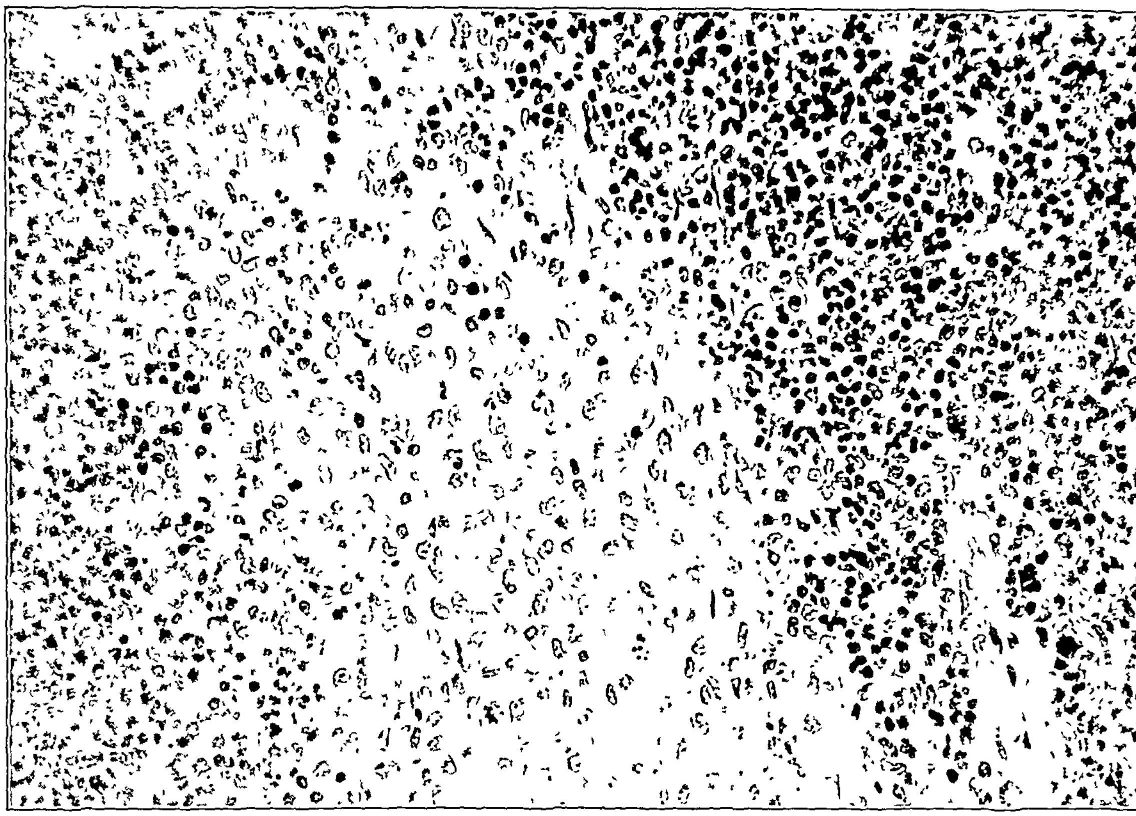

FIG. 4-E

Photomicrograph of the tissue found in the cystic area shown in Figs. 4-A and 4-B. Large mononuclear cells and a great number of eosinophils are seen.

FIG. 4-F

Roentgenogram of the skull, showing a loculated area in the temporal bone. The biopsy of the tissue filling this cavity showed an eosinophilic granuloma.

Blood examination revealed:

White blood cells........	7,350
Polymorphonuclear neutrophils..... .	68 per cen
Eosinophils...	*4 per cent*
Lymphocytes........	27 per cent
Monocytes...........	1 per cent

The roentgenograms of the lef femur showed an ovoid area of rarefac tion in the cortex of the mid-shaft, meas uring 3.5 centimeters in its greates diameter. The surrounding bone wa sclerotic (Fig. 4-G). The lesion of th distal portion of the left humerus was al most completely healed. The lesion in th mid-femur was treated with 1,200 roentgens through two portals. The pain in the thigh disappeared a few days after the roentgenotherapy, and the patient regained his appetite. However, the pain in the thigh recurred six months later, and the roentgenograms showed an increase in the size of the bone lesion and great thickening of the cortex (Fig. 4-H). Four treatments of 200 roentgens each were given through each of two portals over the upper portion of the left femur. The pain disappeared again shortly after roentgenotherapy; and roentgenograms, taken four months later, showed filling in of the rarefied area of the femur with new bone and great thickening of the cortex.

The roentgenograms showed a new destructive lesion at the junction of the left ilium and ischium, medial to the acetabular cavity (Fig. 4-I).

The patient had several other episodes of dull, deep pain in the left thigh. He was seen for the last time in December 1946, when he was free from symptoms and in good health. He still had a slight polyuria, which was well controlled by taking pitressin tannate, one cubic centimeter every seven days. Roentgenographically the lesions of the skull and humerus were healed. The cortex of the middle third of the left femoral shaft was very thick and dense. The area of rarefaction in the pelvic bone was smaller.

Infected gums and loose teeth were the first symptoms of the disease in this patient. These symptoms have been noted early in several other cases diagnosed as Hand-Schüller-Christian disease in this Hospital. This case is of special interest, because a typical eosinophilic granuloma in the humerus and another in the temporal bone were demonstrated in a patient with diabetes insipidus, enlarged spleen and lymph nodes, and infiltration of both upper lung fields. These findings tend to prove Farber's conclusion that eosinophilic granuloma and Hand-Schuller-Christian disease are variants of the same basic disease process.

In addition to the lesions in the humerus and in the temporal bone, which were explored, the patient also had areas of bone destruction in the left femur and in both iliac bones. The lesions in the humerus and in the femur expanded and slightly eroded the cortex. Later these lesions were surrounded by abundant reactive new-bone formation. Moreover, the first roentgenograms of the humerus showed the onion-skin appearance of reactive periosteal bone formation.

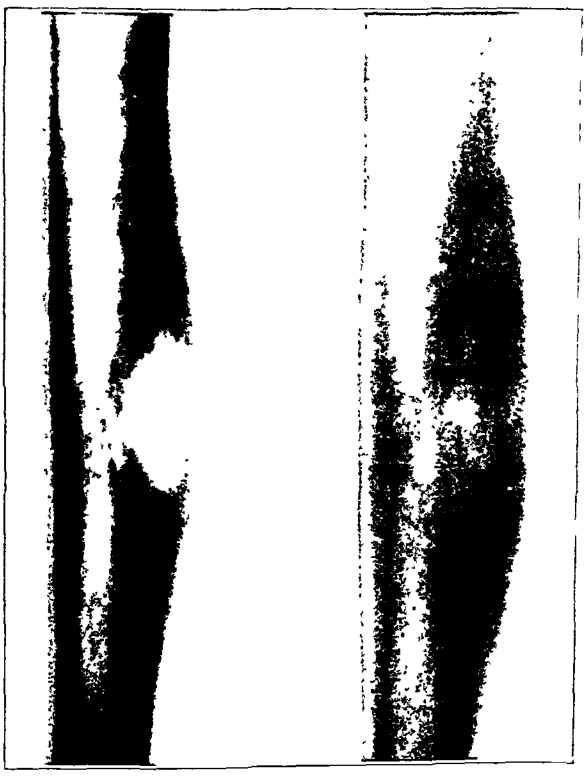

Fig. 4-G Fig. 4-H

Fig. 4-I

Fig. 4-G: Roentgenogram of the left femoral shaft shows an area of rarefaction in the cortex. The surrounding bone is sclerotic.

Fig. 4-H: The same lesion ten months later. There is great thickening of the cortex.

Fig. 4-I: Area of rarefaction in the left ilium, medial to the acetabular cavity.

Another unusual feature in this case was the recurrence of the lesion in the humerus, more than one and one-half years after a very thorough curettage and filling of the cavity with bone chips. The symptoms due to the lesion in the temporal bone were relieved by roentgenotherapy, but reappeared one year later. The area of bone destruction had greatly increased in size; this was also true of the lesion in the femur. Although roentgenotherapy relieved the pain in this patient, it is doubtful that it had any influence on the evolution of the granulomatous lesions. The diffuse infiltration in the upper lung fields, probably due to small granulomatous lesions, disappeared in six months without roentgenotherapy.

The diabetes insipidus in this patient also improved. At first it was necessary to give the patient 0.3 cubic centimeter of pituitrin hypodermically every eight hours to control the polyuria; in December 1946, one cubic centimeter of pitressin tannate in oil every seven

FIG. 5-A

Case 5. Well-outlined osteolytic lesion in the left parietal bone. (Roentgenogram has been reversed.)

days was usually sufficient. It must be pointed out that roentgenotherapy was never given to the pituitary region.

CASE 5. This patient with diabetes insipidus had areas of bone destruction in the skull and fourth rib, and also in the right mastoid, which contained granulomatous tissue with typical areas of eosinophilic granuloma interspersed with extensive fields of foam cells.

In May 1945, G. D., a white boy, four and one-half months old, was first brought to the University Hospitals for treatment of congenital club-foot and a congenital dislocation of the left hip. Physical examination was not remarkable except for the congenital deformities.

In June 1945, a diffuse skin eruption developed, characterized by multiple, well-defined, nodular swellings in the occipital region, several of which had been excoriated. There were many fine maculopapules over the face and many excoriated areas. A diagnosis of infectious dermatitis was made, and sulfathiazole was given by mouth. From that time, the patient had frequent upper-respiratory infections. The ear canals were always full of dried secretions.

In December 1945, the patient was examined again and appeared pale and undernourished. Blood examination showed:

Red blood cells	4,900,000
Hemoglobin	7.09 grams per 100 cubic centimeters
White blood cells	10,300
Polymorphonuclear neutrophils	33 per cent.
Eosinophils	2 per cent.
Lymphocytes	45 per cent.
Monocytes	20 per cent.

The red blood cells showed anisocytosis and poikilocytosis. Total plasma protein was 5 grams per 100 cubic centimeters (albumin 2.6 grams, and globulin 2.2 grams). *Staphylococcus aureus* and diphtheroids were found in cultures of the ear exudate.

In March 1947, it was noticed that the child was drinking large amounts of water and had polyuria. There was also a seborrhoeic dermatitis of the scalp and daily temperature to 101 degrees (probably due to dehydration). One month later a slightly hemorrhagic exudate started to drain from the right ear canal; the posterior canal wall was oedematous, almost touching the anterior canal wall. The cervical glands were enlarged. White-blood-cell count was 11,850· blood cholesterol, 139 milligrams per 100 cubic centimeters. A course of penicillin (30,000 units four times daily for twenty days) was given without any apparent benefit to the patient. The roentgenograms taken at that time showed failure of development of the mastoid cells on the right and sclerosis about the antrum. There was a well-outlined osteolytic lesion, four by three centimeters, in the left parietal bone (Fig. 5-A). Roentgenograms of the chest showed an expanded area of bone destruction in the right fourth rib in the region of the posterior axillary line. The lung fields were clear.

On May 3, 1947, a simple mastoidectomy on the right was performed. A bone defect, about 1.8 centimeters in diameter, was found. The defect was filled with yellowish granulation tissue, which was removed by curettage; the granulations in the external canal were also removed. On histological examination the granulomatous tissue was found to contain areas in which there were numerous histiocytes and eosinophils, interspersed between areas rich in foam cells (Figs. 5-B and 5-C). The patient received a total of 800 roentgens (eight treatments of 100 roentgens each) to the left parietal region and to the lesion in the right fourth rib, and 600 roentgens to the right mastoid.

In July 1947, the patient returned with a bloody discharge from his right ear. A large, glistening, whitish tumor was seen, bulging into the ear canal from the upper posterior portion. This soft tumor was the cause of the bleeding. More x-ray treatments were given to the right ear and to the pituitary region in an effort to control the diabetes insipidus, which was becoming progressively worse. The patient is still under observation.

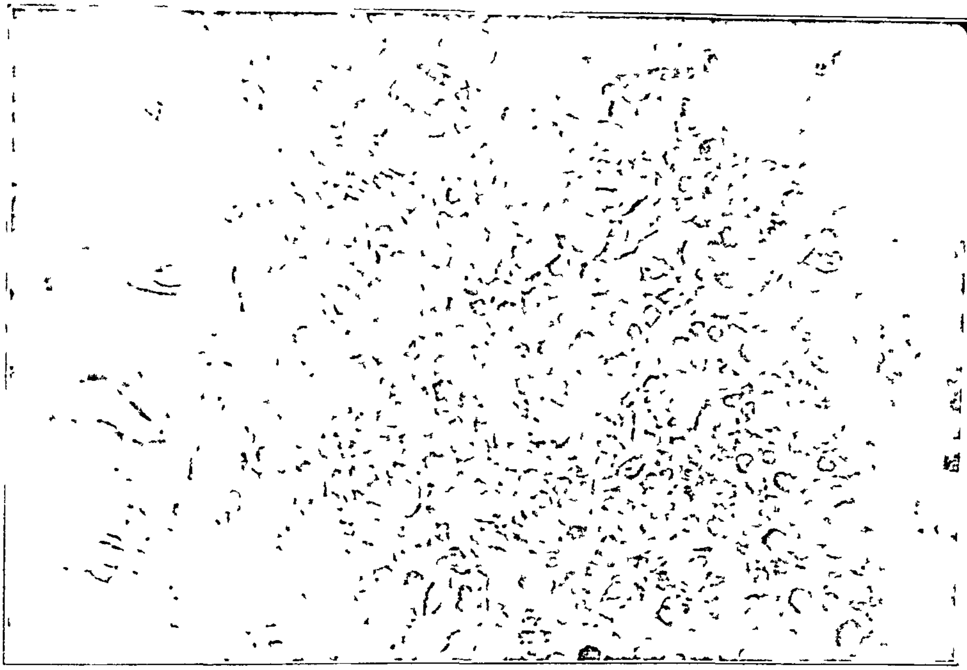

Fig 5-B

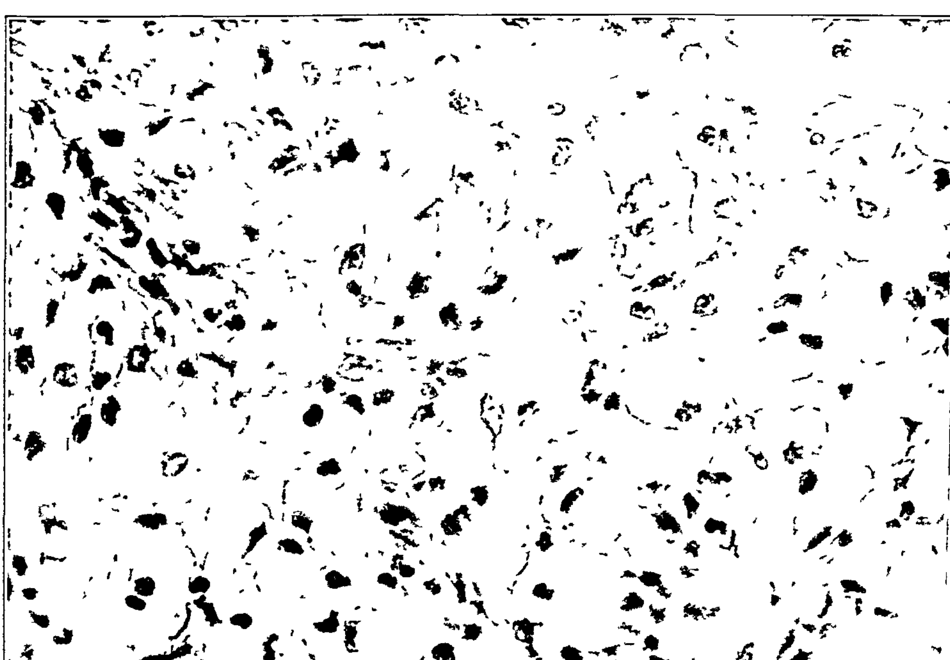

Fig 5-C

Photomicrographs of the tissue obtained from the right mastoid Histiocytes and eosinophils predominate in Fig 5-B Foam cells are very abundant in Fig 5-C

The outstanding finding in this case was the tissue from the right mastoid in which there were a great number of large mononuclear cells and eosinophils, as are seen in the typical eosinophilic granuloma of bone A great number of the large mononuclear cells had a finely vacuolated protoplasm In the tissue surrounding these areas, the eosinophils were very scanty and the protoplasm of the large mononuclear cells appeared definitely

vacuolated. In more distant fields, eosinophils were no longer present; and there were extensive areas of foam cells, which were once thought to be diagnostic of Hand-Schüller-Christian disease.

We believe that the findings, in this case of Hand-Schüller-Christian disease, prove that the eosinophilic granuloma represents the first stage of an evolutive process which, at least in certain cases, undergoes a transformation into a lipogranuloma. This contention is in agreement with Green and Farber's description of the "life history" of the eosinophilic granuloma. Jaffe and Lichtenstein, on the other hand, maintained that "the lesion of eosinophilic granuloma can heal by resolution without passing through a lipogranulomatous stage". This may be true in certain cases of eosinophilic granuloma of bone without other organic disease.

The outcome of this case is very dubious. Although, when last examined, the child's liver and spleen did not appear enlarged, his general condition was poor.

CASE 6. This patient had a diffuse papular eruption over most of her body, hypertrophic and ulcerated gums, exophthalmos, extensive bone defects in the skull, and enlargement of the liver and spleen.

B. R., a white girl, three and one-half years old, was first seen in the Department of Ophthalmology in February 1942, because of exophthalmos of the right eye. She had had dysuria, hypertrophic ulcers of the gums, and a dry scaly lesion of the scalp for a year and a half. Six months prior to admission the patient had fallen and struck her head, following which a mass developed over the right frontal bone, associated with a progressively increasing exophthalmos of the right eye. There was no history of fever.

On admission, examination revealed a severe exophthalmos of the right eye, but the fundi and discs were normal. There was a soft, non-tender mass over the right frontal area and a similar mass over the occipital region. There were abundant greasy scales on the scalp and dried secretions in both ear canals. The skin was dry; there was a generalized papular rash. The teeth were decayed and dirty, and the gums were hypertrophic and ulcerated. Examination of the heart and lungs was negative. The abdomen was rotund, although the liver and spleen were not enlarged to palpation. There was no polyuria. Red and white blood counts were normal. Blood cholesterol was 205 milligrams per 100 cubic centimeters; total plasma lipids, 672 milligrams per 100 cubic centimeters.

Roentgenograms of the skull revealed fairly well-outlined areas of bone destruction in the right frontal, temporal, and occipital bones (Fig. 6-A). Loculated areas of bone destruction were seen in the mandible (Fig. 6-B). There was also an irregular mottling in both lung fields.

A biopsy of the skin papules showed a sharply circumscribed infiltration underneath the basal layer of the epidermis. The infiltrate was made up of large mononuclear cells, with large, round, or crescent-shaped and eccentrically placed nuclei. Occasional large cells with several nuclei were also seen. The cytoplasm was granular and neutrophilic. A few lymphocytes and leukocytes were seen scattered throughout the infiltrate. The connective tissue of the dermis was normal (Fig. 6-C).

A diagnosis of Hand-Schüller-Christian disease was made, and the patient was given small blood transfusions, a low-fat diet, and roentgenotherapy to the skull lesions and posterior lung fields.

Two months after admission the spleen was palpable two finger-breadths below the right costal margin and was smooth and soft. Ten months later, the exophthalmos of the right eye had descreased slightly, but the left eye had begun to protrude. A large, movable, non-tender, subcutaneous mass had developed in the right sternocleidoclavicular region, which was thought to represent involved lymph nodes. Roentgenographically the bone lesions of the skull had decreased in size, but a new area of rarefaction had developed in the upper parietal region. Treatment with a total of 800 roentgens was given to this area.

On physical examination in April 1943, the patient appeared much improved. The liver and spleen were barely palpable, and the mottled infiltration of the lung fields had disappeared. The skull lesions were then treated with 500 roentgens to each parietal area, 600 to the frontal area, and 400 to the occipital area. The same treatment was repeated eleven months later.

In January 1945, a slight exophthalmos was still present, but the roentgenograms of the skull showed that the areas of bone destruction were filled with normal-appearing bone. The patient's general condition was excellent.

On July 4, 1946, the patient complained of intense headache and vomited repeatedly for two days. One month later, it was noticed that the proptosis of both eyes had increased. There was an enlarged, non-tender lymph node in the angle of the right jaw, and two tender, depressed areas, approximately two centimeters in diameter, could be palpated in the right parietal and frontal bones. They were visible in the roentgenograms as round areas of bone destruction. A new course of roentgen treatments was given to the skull lesions.

The patient did not improve and was readmitted to the Hospital in June 1947, with a moderate increase of the exophthalmos and great bulging over the skull defects. The vision had diminished. While in the Hospital, the eyes became more prominent and a left facial paresis developed, with homonomous hemianopsia

FIG. 6-A

FIG. 6-B

Fig. 6-A: Case 6. Roentgenogram of the skull reveals extensive areas of bone destruction in the right frontal, temporal, and occipital bones. (Roentgenogram has been reversed.)

Fig 6-B: Loculated areas of bone destruction in the right mandible.

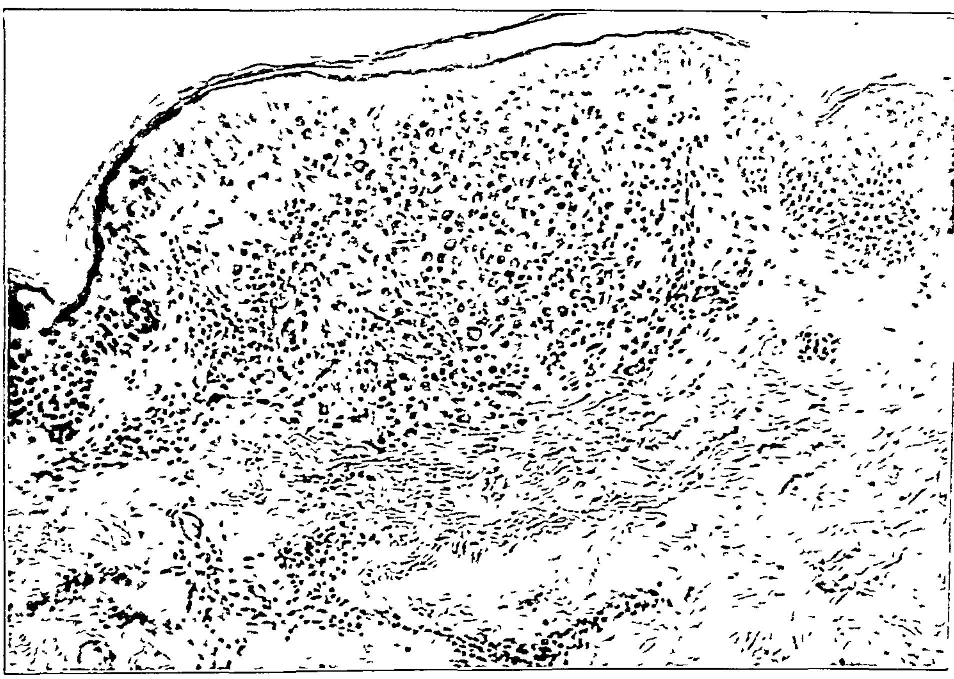

FIG. 6-C

Photomicrograph of the skin papules. A circumscribed infiltrate, composed mostly of large mononuclear cells, is seen underneath the epidermis. Lymphocytes are conspicuous at the periphery of the infiltrate.

and cupping of the optic discs and blurred disc margins. Alternated motion rate was somewhat impaired in the left arm and left leg, and the left biceps reflex was hyperactive. These symptoms were probably due to a lesion in the right temporoparietal cerebral area or perhaps to the compression of the same area of the brain by the bulging granulomatous tissue in the skull defect. The patient became stuporous and had convulsions on two occasions. The liver was two finger-breadths below the costal margin and the spleen was barely palpable. There was no noticeable polyuria and the specific gravity of the urine varied from 1.003 to 1.014. The condition of the child was poor at the time of her discharge from the Hospital.

This patient had a typical Hand-Schüller-Christian syndrome, although she had no diabetes insipidus. She improved greatly and was symptomless, except for a slight exophthalmos, for a period of over three years. How much of this improvement can be attributed to the roentgenotherapy is not known. Then came an acute exacerbation of the disease, which did not respond to roentgenotherapy. The liver and spleen became enlarged, and the

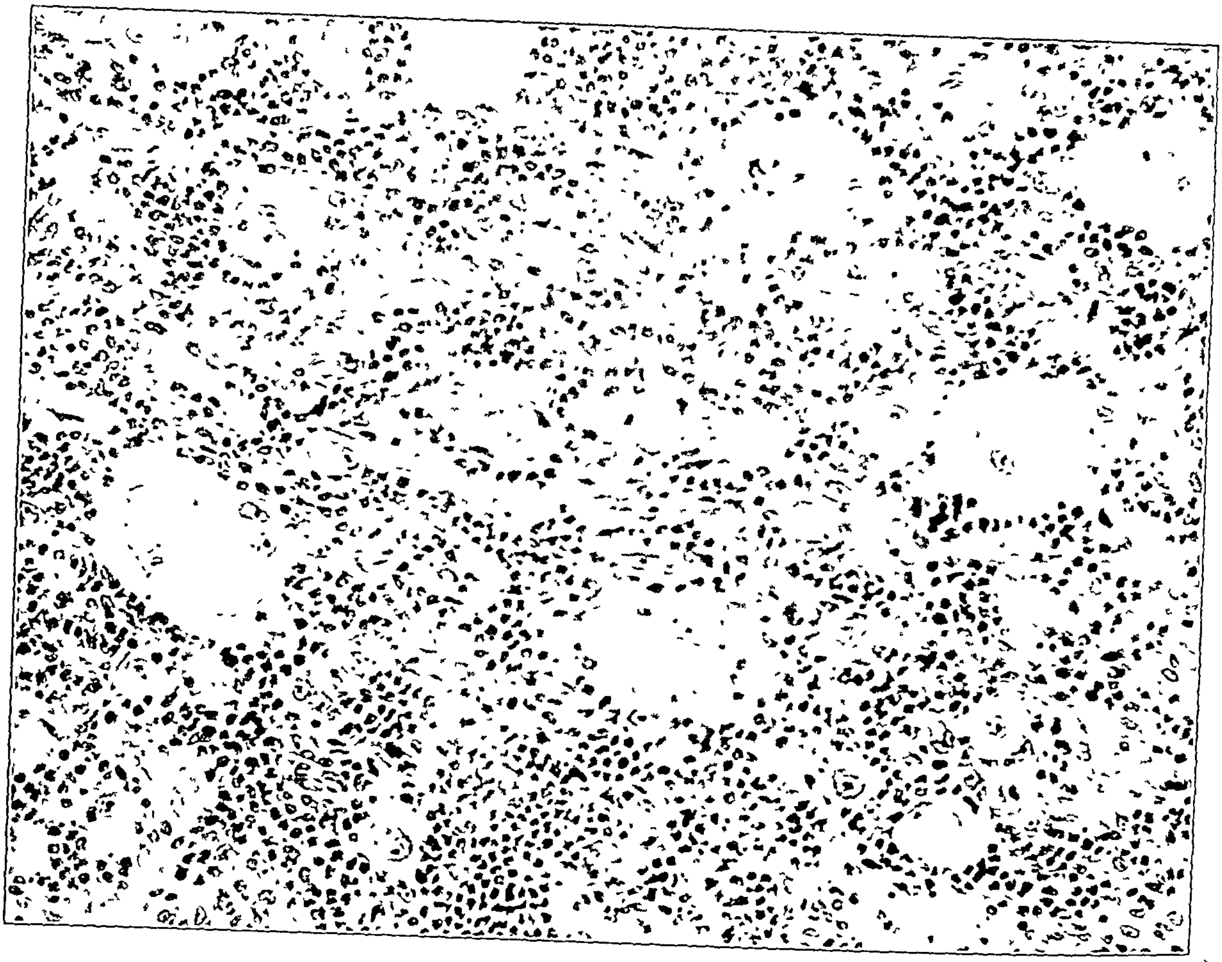

FIG. 7-A

Case 7. Photomicrograph of the biopsy specimen from a small subcutaneous nodule. Large mononuclear cells and polynuclear giant cells are seen.

skull defects, which had healed, reappeared. The lesion in the right parietal and temporal bones was bulging markedly, and symptoms of a lesion in the right temporoparietal cerebral area appeared. These symptoms are very rarely seen in Hand-Schüller-Christian disease.

It is of interest to note that the biopsy of skin, taken at the onset of the disease, showed an infiltrate beneath the epidermis, made up of large mononuclear cells, probably histiocytes, with coarsely granular cytoplasm. This lesion is typical of this group of diseases, and it can be seen in both Hand-Schüller-Christian disease and Letterer-Siwe disease. It is quite similar to the skin lesion seen in Case 8. The prognosis for this patient is grave.

CASE 7. This patient had a small encapsulated tumor in the subcutaneous tissue of the back, which on biopsy was found to be made up of a very strange-looking granulation tissue. No diagnosis was made until six months later, when a definite clinical picture of Letterer-Siwe disease developed.

C. S. was first called to our attention at the age of one and one-half years, when the local physician forwarded the histological sections of this subcutaneous nodule for diagnosis. It was described as being "the size of a pencil eraser, encapsulated, and freely movable". The microscopic picture was that of a chronic granulomatous tissue, in which there were numerous giant cells of varying sizes; the nuclei varied in number from eight to ten, and were situated at the periphery of the cells. They were large, pale, reticular, and contained very distinct nucleoli. The protoplasm was finely granular and very abundant. There were also many large mononuclear cells with protoplasm and nuclei which were similar to the giant cells. Neutrophils, lymphocytes, and eosinophils were seen in moderate numbers (Fig. 7-A). We were unable to make a diagnosis from these sections at that time.

Six months later, in May 1942, the child was admitted to the Pediatric Service for study and diagnosis. The parents stated that a generalized itching had developed, and they had noticed a lump in the right side of the abdomen five months prior to admission. Two months later, pneumonia developed, with ascites and oedema of the lower extremities. He had had three weeks of digitalis therapy.

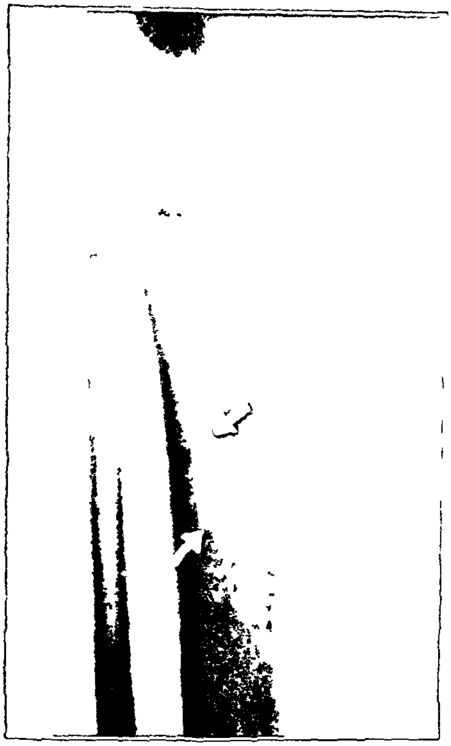

Fig 7-B

Fig 7-C

Fig 7-B Roentgenogram shows a small area of rarefaction in the upper end of the right tibia

Fig 7-C Roentgenogram of the skull shows four small areas of rarefaction in the vault

Fig 7-D Roentgenogram of the chest shows small infiltrative lesions throughout both lung fields

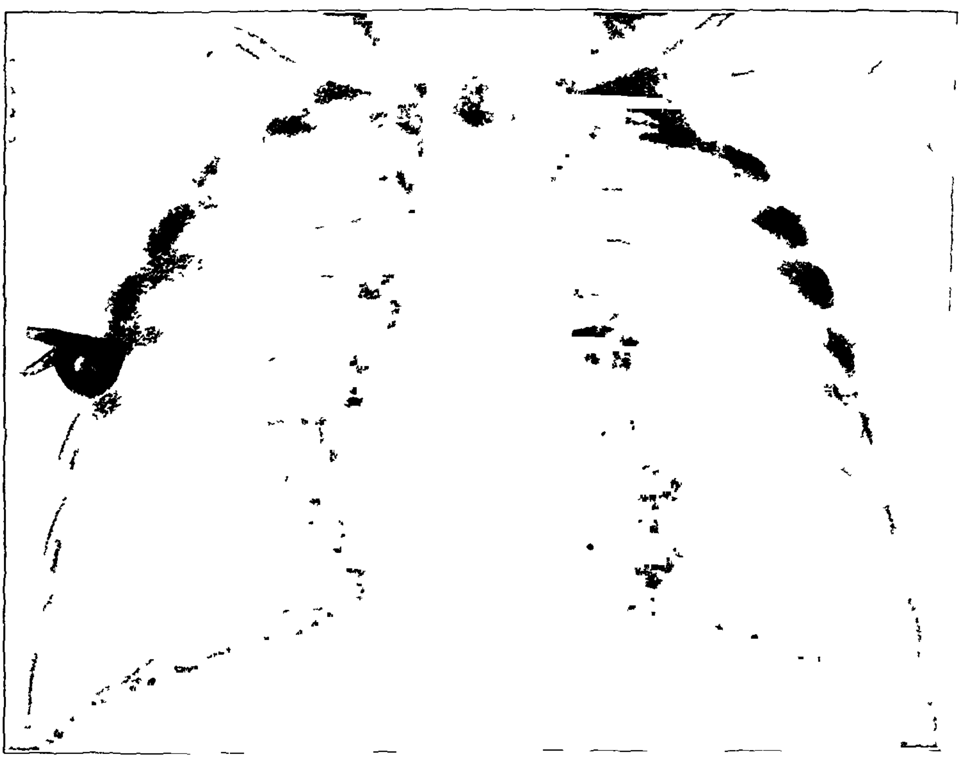

Fig. 7-D

The physical examination on admission revealed a well-developed, well-nourished, two-year-old white boy. The abdomen was markedly enlarged, and the liver extended below the umbilicus. The lower edge was smooth and firm, but there was a large nodular mass on the anterior surface below the right costal margin. The spleen was also enlarged and had a smooth, soft, rounded edge. There were no lesions of the skin to account for the itching. The inguinal and axillary lymph nodes were moderately enlarged. Urine examinations were negative. The red-blood-cell count was 4,000,000; hemoglobin, 11 grams per 100 cubic centimeters. The white-blood-cell count was 13,800. Blood cholesterol was 255 milligrams per 100 cubic centimeters; total lipids, 883 milligrams per 100 cubic centimeters. Plasma proteins, albumin, and globulin were normal. Wassermann test was negative.

The roentgenograms showed a small, irregular area of rarefaction in the upper end of the right tibia (Fig. 7-B). A lateral roentgenogram of the skull demonstrated four sharply circumscribed areas of rarefaction in the vault, varying in size from five to ten millimeters in diameter (Fig. 7-C). A roentgenogram of the chest showed innumerable opaque infiltrative lesions, one to two millimeters in diameter, uniformly distributed throughout both lung fields (Fig. 7-D).

The patient remained in the Hospital for three weeks, during which time he was afebrile. He was given a low-fat diet and received roentgenotherapy,—800 roentgens to the involved tibia, 600 roentgens to the liver, 800 roentgens to the chest, and 600 roentgens to the skull. The liver was treated very cautiously, with not more than 50 roentgens per treatment, and only one side of the chest was irradiated at a time.

The patient returned to the Hospital on August 3, 1942, showing some improvement. The abdomen was still distended. The roentgenograms demonstrated that the punched-out areas of the skull were much smaller. The lungs showed very slight improvement, and there was no change in the lesion of the tibia. No treatment was given at that time.

In October 1942, the patient began itching again. There had been no great change in the size of the upper portion of the abdomen. The roentgenograms showed that the skull defects had disappeared, the lungs were not improved, and the tibial lesion was still present. No roentgenotherapy was given at that time.

The patient did not return to the Hospital until April 1944. He had been up and about until December 1942, when pneumonia had developed and he had been confined to bed for three months. In September 1943, the patient had begun passing large amounts of urine at frequent intervals, he had lost his appetite, and ascites had developed. Many teeth had become loose and had fallen out, and the itching had increased in severity. Jaundice had been noticed in the sclera about three weeks prior to admission. The stools had been light yellow to gray-white.

The child appeared poorly developed and malnourished. The skin was dry, and there were many excoriations. A few remaining teeth were carious and loose. Blood pressure was 100 systolic, 75 diastolic; examination of the heart and lungs was negative. There was ascites and the superficial veins of the abdomen were distended. The liver was nodular and enlarged as on previous admissions. The spleen was also enlarged. Tendon reflexes were hypo-active. The child had a very severe polyuria, and the specific gravity of the urine was 1.003. No sugar or albumin was found in the urine.

Roentgenograms of the chest continued to show extensive infiltration in both lung fields, which had not changed since the roentgenograms taken on the first admission. The skull appeared normal, and the sella turcica was of normal size. The child was again given roentgenotherapy,—700 roentgens to the pituitary region, 700 roentgens to the liver, and 600 roentgens to the mandible.

Following this treatment, he became progressively worse, with increasing ascites and oedema of both lower extremities; he expired on February 20, 1945. No autopsy was performed.

Certain clinical findings in this case, such as the enlarged liver and spleen, moderate enlargement of all palpable lymph nodes, moderate anaemia and leukocytosis, and extensive infiltration in both lungs, suggest Letterer-Siwe disease[1]. However, other findings — such as diabetes insipidus, moderately high blood cholesterol, and total lipids — are more characteristic of Hand-Schüller-Christian disease. The peculiar histological structure of the subcutaneous growth in the back is difficult to classify, but is more indicative of a lipogranuloma than of the lesions found in Letterer-Siwe disease. Skull defects, such as this patient had, have been described in both diseases. This patient, then, showed characteristics of both diseases; the case emphasizes that Letterer-Siwe disease and Hand-Schüller-Christian disease are but two manifestations of the same pathological process.

CASE 8. J. M., a fourteen-month-old white girl, was first seen in this Hospital in February 1942. When she was six months of age, a rash had developed over the head and body, which was diagnosed as infantile eczema. At eleven months of age, it was noticed that she did not use her left arm and that there was a tumor in the left shoulder which continued to grow slowly.

The patient appeared cachectic; the skin over the scalp and trunk was covered with a small papular rash of an almost vesicular, seborrhoeic type of lesion. There were deep, necrotic ulcers of both labia, which

were surrounded by considerable swelling and redness. The ear canals were filled with thick, yellow, cheesy exudate, and the ear drums were reddened and thickened. The mouth showed hypertrophy of the gingiva throughout. Examination of the lungs and heart was negative. Both the liver and spleen were moderately enlarged. There was a large mass, 5 by 3 by 3 centimeters, in the upper portion of the left humerus, and the deltoid action was absent. The mass was tender, soft, fixed, and non-fluctuant. The fundi of both eyes were normal. Reflexes and sensation were normal. The Kline test and Wassermann reaction were negative.

Blood examination showed:

Red blood cells	2,600,000
White blood cells	11,200
Polymorphonuclear neutrophils	58 per cent.
Lymphocytes	23 per cent.
Monocytes	9 per cent.
Degenerated cells	4 per cent.
Large immature cells (probably of the monocytic series)	6 per cent.

Blood cholesterol was 191 milligrams per 100 cubic centimeters. The serum calcium, phosphorus, and phosphatase values were normal.

The roentgenograms demonstrated an extensive area of bone destruction in the upper end of the humeral shaft, measuring five centimeters in length and four centimeters in width. The proximal humeral epiphysis was not invaded. The cortex was perforated and there was much periosteal reaction with partial destruction of the newly formed periosteal bone (Fig. 8-B). In the upper end of the right femoral shaft, there was an extensive area of bone destruction. The outer cortex was perforated, and there was abundant periosteal new bone at the lower margin of the lesion (Fig. 8-A). The roentgenograms of the other bones and of the chest were negative.

The mass in the left humerus was explored. The cortex was paper-thin, and underneath it there was a firm, rather uniform, pinkish tissue with a slight yellowish cast. On microscopic examination, this tissue appeared to be of uniform structure, with a fine fibrillar network. Large mononuclear cells were predominant; their nuclei were pale, oval, or round with finely reticular chromatin. Mitotic figures were abundant. A few giant cells with three to four nuclei were seen. Leukocytes, neutrophils, and a few eosinophils were scattered throughout the section (Fig. 8-D). The newly formed periosteal bone at the periphery was being invaded by the tumor. Sudan III stains showed some yellow-staining granules in a few mononuclear cells, which could be interpreted as lipoid material.

A biopsy of the skin of the anterior wall of the chest was also obtained. The epidermis was irregularly acanthotic. In some areas of the epidermis there were small, well-outlined collections of large mononuclear cells and a few leukocytes. The papillary layer of the cutis was oedematous and contained peculiar large mononuclear infiltrates. The nuclei of these cells were round or shaped like a horseshoe. Abundant mitotic figures were seen (Fig. 8-C). The subepidermal oedema had progressed to vesicle formation in several places, and contained large mononuclear cells and leukocytes. The lower and mid-cutis were essentially normal. This skin lesion was clinically and pathologically very similar to that of Case 6.

Roentgenotherapy—a total of 800 roentgens to the left humerus and the right upper femur—was given. The mass in the left arm had decreased in size a few weeks after the treatment and was less tender. More x-ray treatments were given to the left humerus and the right femur in June 1942.

The child was brought back to the Hospital on August 31, 1942, and he appeared to be nearly moribund. There was nodular hypertrophy of the gums and marked jaundice. The liver and spleen had increased in size. There was swelling in the left supraclavicular region. On the roentgenograms the lesion of the femur appeared smaller; the lesion of the humerus showed no change. The patient became progressively weaker and died in November 1942. No autopsy was performed.

The lesion in the left humerus was very extensive and destructive. The upper arm was tender, but not particularly painful. On the roentgenograms the lesion appeared to be more expansive than infiltrative, although it had destroyed the bone cortex of half the humerus. The epiphyseal plate was not invaded. The biopsy showed that the soft tissues of the upper arm had not been invaded. The lesion in the upper portion of the femur, although destructive, was well outlined by normal-appearing bone in its upper and lower margins. The outer cortex had been perforated. The biopsy of the area of bone destruction in the humerus showed a lesion compatible with Letterer-Siwe disease. The clinical findings and the rapid downhill course of the patient were typical of that disease.

The skin lesions observed in this patient appeared clinically and microscopically to be quite similar to the lesions observed in Case 6 (Fig. 6-C), which was a typical case of Hand-Schüller-Christian disease. In Case 6, however, the infiltrates were smaller, but their cytology was identical to the cytology in Case 8.

DISCUSSION OF FINDINGS

These eight cases demonstrate that eosinophilic granuloma of bone, Hand-Schüller-Christian disease, and Letterer-Siwe disease represent different clinical and anatomical manifestations of the same underlying pathological process.

The solitary eosinophilic granuloma of bone is the mildest clinical form of this group of diseases. The local symptoms are tumor, tenderness, and very slight pain. (The pain was more severe on weight-bearing in Case 2 because the lesion had destroyed a great portion of a weight-bearing bone.) There are no general symptoms. The roentgenograms show a more or less clear-cut defect, well outlined by normal-appearing bone. There may be reactive periosteal new-bone formation. (A pathological fracture resulted from the destruction of the bone cortex by the expanding lesion in Case 2.)

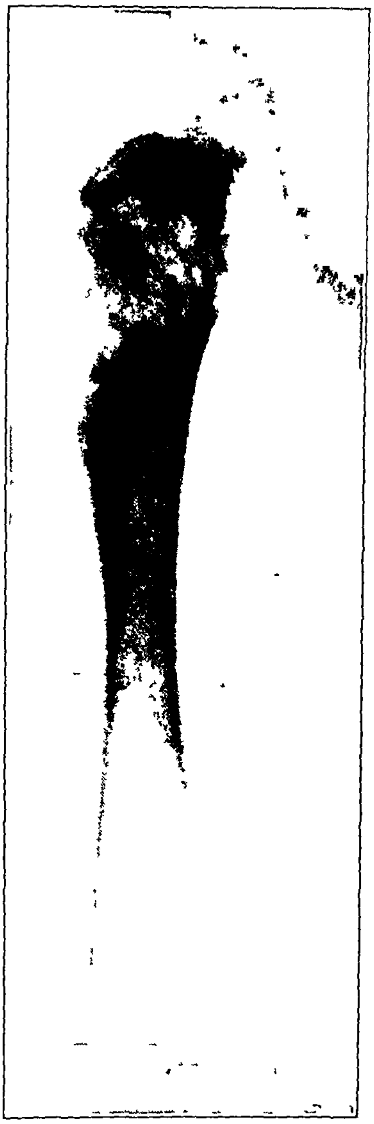

FIG. 8-A

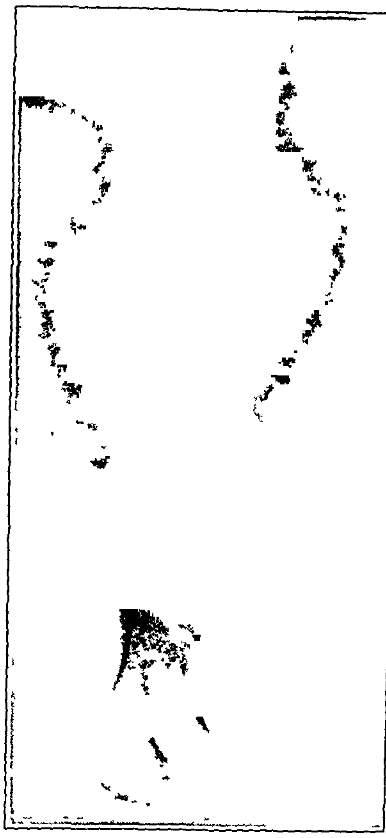

FIG. 8-B

Fig. 8-A: Case 8. Roentgenogram of the right femur shows an extensive area of bone destruction. There is periosteal new-bone formation at the lower margin of the lesion.

Fig. 8-B: Roentgenogram of the left humerus shows a very extensive area of bone destruction. The upper humeral epiphysis is not invaded.

The case of a solitary eosinophilic granuloma of bone has a good prognosis, and the lesion does not recur after its surgical removal or after roentgenotherapy. However, particular malignant forms may occur, which are resistant to treatment and which may recur, producing great bone destruction. Even in these instances, the general outlook for the patient is good.

Patients with multiple eosinophilic granulomata may or may not show signs of general illness. One patient, a male with multiple eosinophilic granulomata, has been followed in these Hospitals for seventeen years. He was three years old when the first lesion appeared in the femur, which was supposedly "drained" by his physician. Since then, he has had areas of bone destruction in both femora, both tibiae, both iliac bones, multiple ribs, the right clavicle, the right ulna and radius, and the mandible, and multiple lesions in the skull. In addition, he has had several fractures. Many of these lesions did not produce symptoms, although pain of six months' to one year's duration accompanied the first lesions in both femora. No treatment was given, and the roentgenograms showed that the areas of bone destruction had been partially or totally filled with new bone. This patient had had slight persistent leukocytosis with 4 to 5 per cent. eosinophils, but no other general symptom.

Another patient (Case 3) with multiple granulomatous lesions in several bones had signs of more generalized involvement. His disease represented a transitional form between multiple eosinophilic granuloma and Hand-Schüller-Christian disease.

Case 4 was a patient with Hand-Schüller-Christian disease and multiple eosinophilic granulomata. In Case 5, lesions of eosinophilic granuloma were seen in close proximity to

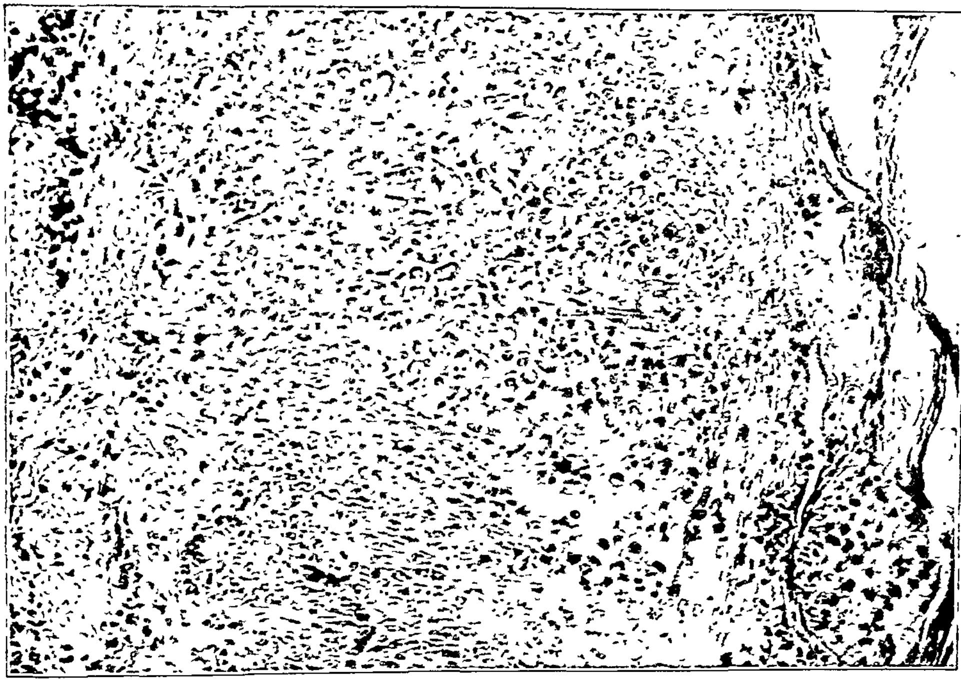

Fig 8-C

Photomicrograph of the biopsy specimen from the skin. Collections of large mononuclear cells are seen in the epidermis and underneath the basal-cell layer.

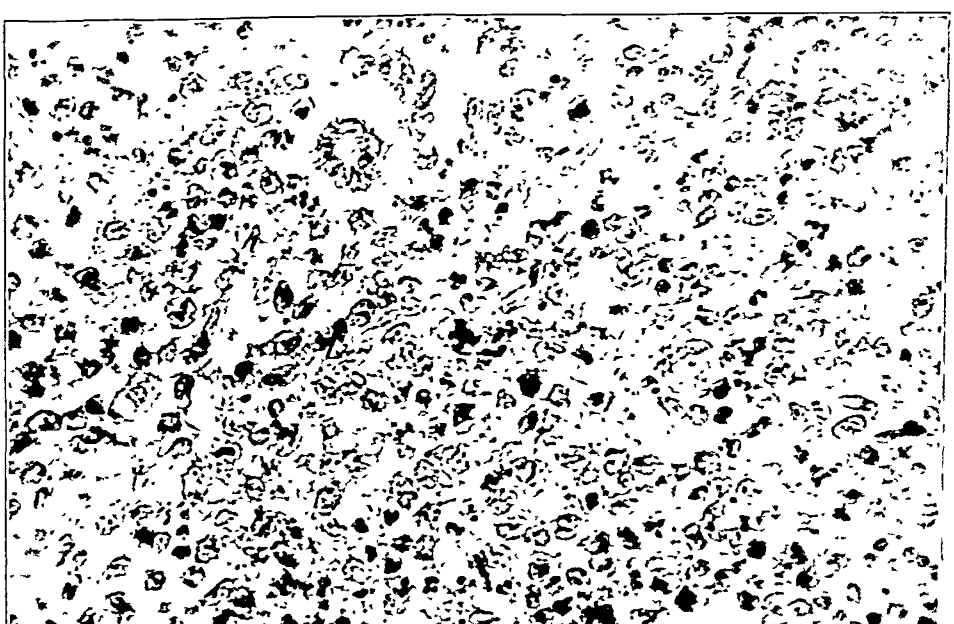

Fig. 8-D

Photomicrograph of the biopsy specimen obtained from the left humerus. Large mononuclear cells with pale nuclei and leukocytes are seen.

DISCUSSION OF FINDINGS

These eight cases demonstrate that eosinophilic granuloma of bone, Hand-Schüllei Christian disease, and Letterer-Siwe disease represent different clinical and anatomica manifestations of the same underlying pathological proces:

The solitary eosinophilic granuloma of bone is the mild est clinical form of this group of diseases. The local symptom are tumor, tenderness, and very slight pain. (The pain wa more severe on weight-bearing in Case 2 because the lesion ha destroyed a great portion of a weight-bearing bone.) Ther are no general symptoms. The roentgenograms show a mor or less clear-cut defect, well outlined by normal-appearin bone. There may be reactiv periosteal new-bone formatioı (A pathological fracture re sulted from the destruction c the bone cortex by the expanc ing lesion in Case 2.)

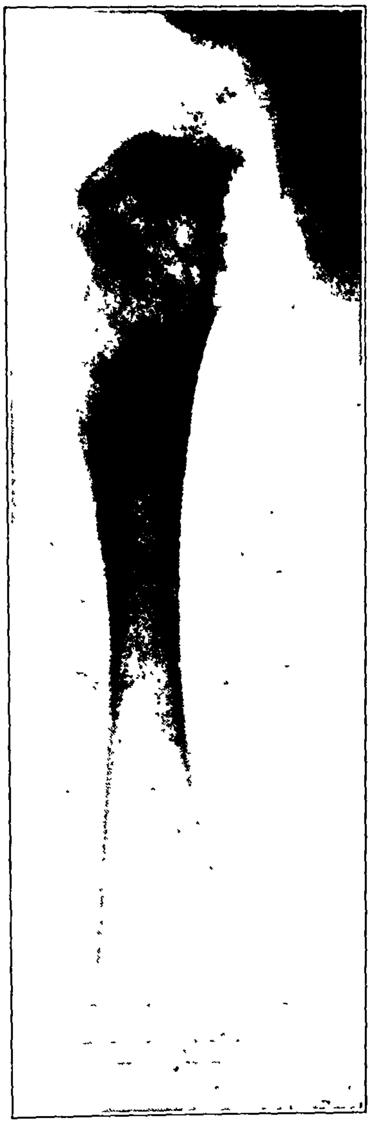

Fig. 8-A

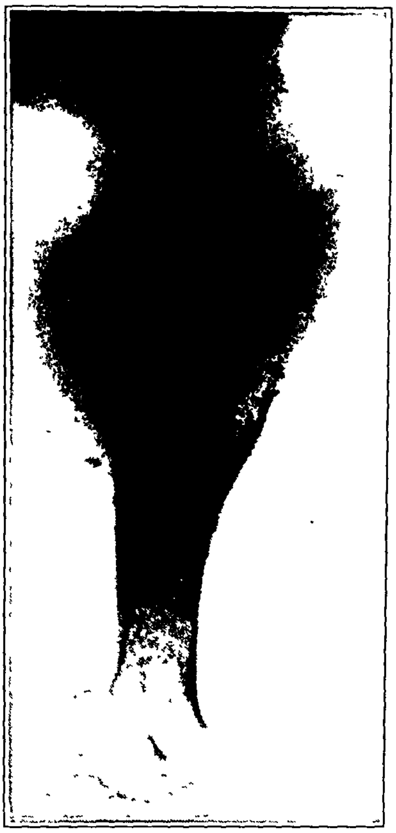

Fig. 8-B

Fig. 8-A: Case 8. Roentgenogram of the right femur shows an extensive area of bone destruction. There is periosteal new-bone formation at the lower margin of the lesion.

Fig. 8-B: Roentgenogram of the left humerus shows a very extensive area of bone destruction. The upper humeral epiphysis is not invaded.

The case of a solitary eosir ophilic granuloma of bone ha a good prognosis, and the lesio does not recur after its surgica removal or after roentgenc therapy. However, particula malignant forms may occu which are resistant to trea ment and which may recu producing great bone destruc tion. Even in these instance: the general outlook for the pa tient is good.

Patients with multipl eosinophilic granulomata ma or may not show signs of ger eral illness. One patient, male with multiple eosinophili granulomata, has been followe in these Hospitals for seventee years. He was three years ol when the first lesion appeare in the femur, which was sup posedly "drained" by his physician. Since then, he has had areas of bone destruction ii both femora, both tibiae, both iliac bones, multiple ribs, the right clavicle, the right ulna and radius, and the mandible, and multiple lesions in the skull. In addition, he has hac several fractures. Many of these lesions did not produce symptoms, although pain of si months' to one year's duration accompanied the first lesions in both femora. No treatmen was given, and the roentgenograms showed that the areas of bone destruction had beer partially or totally filled with new bone. This patient had had slight persistent leukocy- tosis with 4 to 5 per cent. eosinophils, but no other general symptom.

Another patient (Case 3) with multiple granulomatous lesions in several bones had signs of more generalized involvement. His disease represented a transitional form between multiple eosinophilic granuloma and Hand-Schüller-Christian disease.

Case 4 was a patient with Hand-Schüller-Christian disease and multiple eosinophilic granulomata. In Case 5, lesions of eosinophilic granuloma were seen in close proximity to

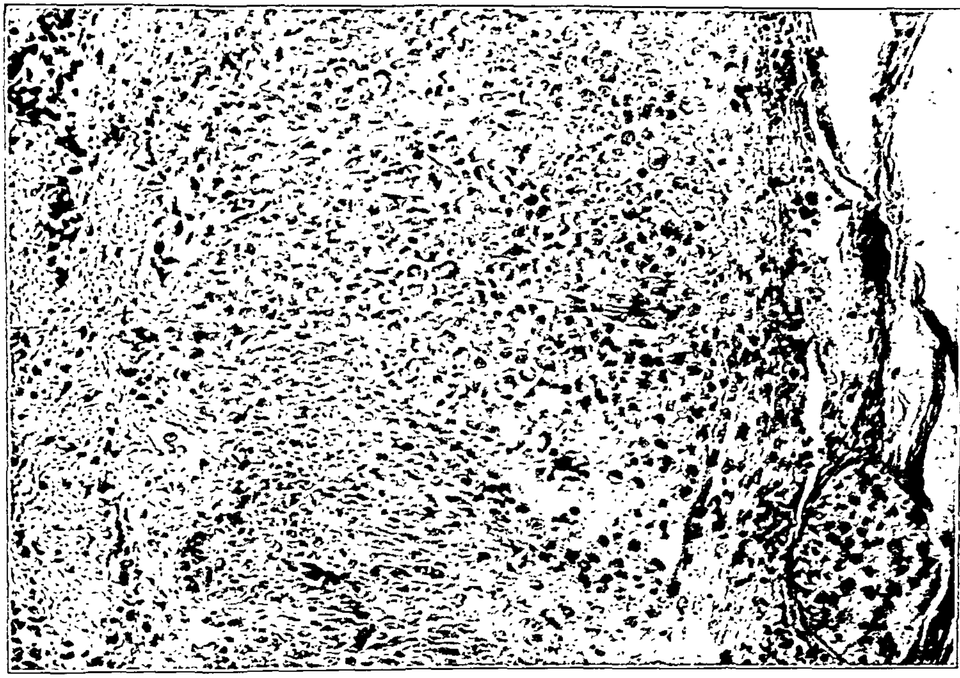

FIG. 8-C

Photomicrograph of the biopsy specimen from the skin. Collections of large mononuclear cells are seen in the epidermis and underneath the basal-cell layer.

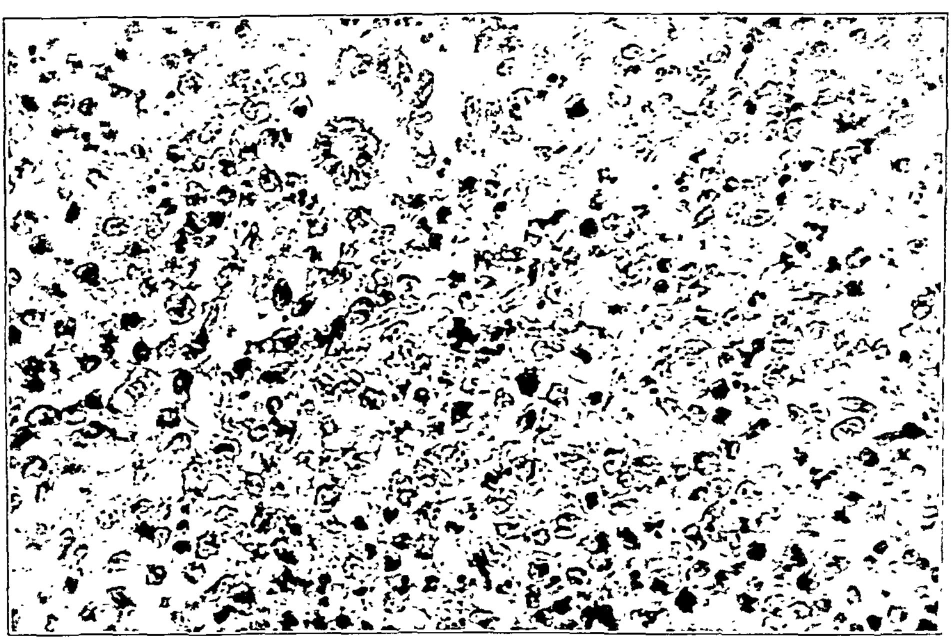

FIG. 8-D

Photomicrograph of the biopsy specimen obtained from the left humerus. Large mononuclear cells with pale nuclei and leukocytes are seen.

extensive fields of foam cells in the tissue removed from an area of bone destruction in the mastoid. This patient had had several other areas of bone destruction and diabetes insipidus. It is obvious, then, that there exist intermediary forms between multiple eosinophilic granuloma and Hand-Schüller-Christian disease; and that identical pathological lesions can be seen in both diseases. In a similar way, Cases 6 and 7 can be considered to be transitional forms between Hand-Schüller-Christian disease and Letterer-Siwe disease. The solitary eosinophilic granuloma of bone and the uncomplicated multiple eosinophilic granulomata form a distinct clinical group. However, from a clinical point of view, it would be convenient to group cases of multiple eosinophilic granulomata of bone, with similar involvement of other organs, under a common heading with Hand-Schüller-Christian disease and Letterer-Siwe disease. Six of these cases (Cases 3, 4, 5, 6, 7, and 8) belong to this common group.

The age of the patients of this group at the onset of symptoms varies, although it is often during early childhood that symptoms appear, usually in an insidious manner. Skin lesions, in the form of a generalized papular rash of minute lesions, and seborrhoeic dermatitis of the scalp are frequently seen.

A peculiar inflammation of the gingivae, with hypertrophy and, occasionally, ulceration of the gums, is frequently an early symptom. The roentgenograms of the maxilla showed small cystic areas of bone destruction adjacent to the alveoli in three cases.

The ear canals are inflamed, tender to palpation, and filled with a dry, yellow exudate. A bloody discharge, due to the growth of granulomatous tissue into the ear canal, appeared in one patient (Case 5). The mastoid is often tender and the roentgenograms show a more or less extensive defect in that bone. Exophthalmos is seen in some patients.

Moderate enlargement of several or all of the palpable lymph-node groups was found in all of the patients. The spleen and the liver may be enlarged.

The physical examination of the chest is invariably negative. However, a more or less extensive infiltration in both lung fields is often seen in the roentgenograms. The infiltration is formed by small lesions, uniformly distributed.

Diabetes insipidus may be an early symptom. In Case 4 the diabetes insipidus improved concurrently with improvement of bone lesions. Water metabolism is often normal.

The red-blood-cell count may be slightly low; the leukocyte count is often elevated. The differential count shows an increase of the neutrophils. Slight eosinophilia may or may not be present.

The blood cholesterol and total lipids are usually within normal limits. Blood Wassermann tests and Kline reactions are negative.

Bone lesions are very frequent. The skull was involved in all of the patients but one, where the lesions were limited to the extremities. Any bone may be affected, even metacarpals and phalanges, as seen in Case 3. The roentgenographic appearance of the bone lesions in Hand-Schüller-Christian and in Letterer-Siwe diseases was usually identical to that of the lesions of solitary or multiple eosinophilic granulomata. The areas of bone destruction were frequently sharply outlined and the surrounding bone appeared normal. Very destructive lesions were seen in one patient (Case 8), with destruction of the cortex and abundant reactive periosteal new-bone formation.

All of the bone lesions explored were found to be filled with granulomatous tissue, made up of a great number of large, mononuclear cells, probably histiocytes, and a small number of leukocytes. Except in the typical eosinophilic granuloma, eosinophils were not present and the cytoplasm of the histiocytes appeared to be finely or coarsely vacuolated. In other cases, the granulomatous tissue was made up of extensive sheets of foam cells. Intermediary stages between these different types of granulomatous tissue were seen in one lesion in Case 5. The structures surrounding the areas of bone destruction were in no instance infiltrated by the granulomatous tissue, even in the most malignant-appearing lesions.

It is not certain that the evolution of the lesions of eosinophilic granuloma always follows an established pattern. It seems that the healing of the lesions by resolution, as explained by Jaffe and Lichtenstein, is possible, and probably occurs frequently in the uncomplicated cases of eosinophilic granuloma. On the other hand, eosinophilic granuloma may pass through a lipogranulomatous stage before healing. This is probably most frequently the case in patients with Hand-Schüller-Christian disease.

The cause of this group of diseases is unknown. The clinical findings and the histological characteristics of the lesions seem to indicate that the inciting factor may be a low-grade infection. However, repeated attempts to find an infectious agent have failed. More research will be necessary to arrive at a definite conclusion. The nature of the pathological lesions in this group of diseases is completely different from the character of the lesions found in Niemann-Pick disease and other lipoid-storage diseases. Hand-Schüller-Christian disease and Letterer-Siwe disease should probably not be included in the group of diseases caused by disturbed lipoid metabolism[3].

It is also unjustifiable to classify all xanthomata of bone in the same group with eosinophilic granuloma. A bone xanthoma in some cases may be a terminal phase of a lesion which initially was a low-grade infection, an eosinophilic granuloma, or secondary to trauma. Xanthoma cells are frequently seen in chronic osteomyelitis, but they are in no way specific of any one type of bone lesion.

The evolution of these diseases often is not affected by any form of treatment. As a general rule, the older the patient, the more favorable the prognosis. The fatalities usually occur in children, after a more or less protracted course, but patients over ten years of age usually survive.

Roentgenotherapy was given to the bone lesions in all of the patients. The pain was relieved in each case a few days after treatment; however, it was difficult to evaluate the effect of the roentgen treatments on the development and final outcome of the bone lesions and on the disease as a whole. In Case 3, where one of the bone lesions and one group of lymph nodes were not treated, the pain persisted in the untreated lesion, but rapidly disappeared in the treated areas; yet the bone lesions filled in with normal-appearing bone at the same rate, regardless of whether or not they had been treated. Likewise, the treated and untreated cervical lymph nodes regressed at the same rate. In Case 4, the infiltration of the lung disappeared without treatment. The infiltration in Case 6 disappeared one year after roentgenotherapy; yet in Case 7, there was no change in the pulmonary infiltration despite roentgenotherapy. Notwithstanding these experiences, the author believes that roentgen treatments usually have a favorable influence upon the granulomatous lesions in eosinophilic granuloma, Hand-Schüller-Christian disease, and Letterer-Siwe disease, and that roentgenotherapy should always be given to these patients until the etiology of these diseases has been discovered.

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THE RESPONSE OF THE QUADRICEPS FEMORIS TO PROGRESSIVE-RESISTANCE EXERCISES IN POLIOMYELITIC PATIENTS *

BY THOMAS L. DELORME, M.D., ROBERT S. SCHWAB, M.D., AND ARTHUR L. WATKINS, M.D., BOSTON, MASSACHUSETTS

The response of poliomyelitis-weakened muscles to progressive-resistance exercises has been studied in twenty-seven quadriceps femoris muscles. The effectiveness of these power exercises for increasing strength in normal muscles and in those atrophied as a result of immobilization prompted this study [2,3,5,6,8,9,11,12,13,17]. The rationale for treatment was based upon the hypothesis that, in poliomyelitis, the remaining innervated muscle fibers are normal and, therefore, possess the same potentialities for hypertrophy and power as normal muscles. Thus the degree of the muscle's response to exercise should be directly proportional to the number of muscle fibers with intact nerve supply. Results clearly indicate that poliomyelitis-weakened muscles respond in much the same fashion as do normal muscles, but to a degree proportionate to the number of remaining innervated muscle fibers.

Method of Exercise

Three quadriceps femoris exercises were employed in this study. For muscles of sufficient strength to completely extend the leg against gravity, the exercise shown in Figure 1 was used. Weaker muscles were exercised with the assistance of gravity in the manner illustrated in Figure 2. In addition all muscles, regardless of grade, performed the exercise shown in Figure 3. Thus each muscle performed two exercises. Each exercise was performed for thirty repetitions, which were broken up into three sets of exercises with ten repetitions per set. A rest period of about one minute was allowed between each set of ten repetitions. A complete exercise period, therefore, consisted of two exercises, each performed for thirty repetitions.

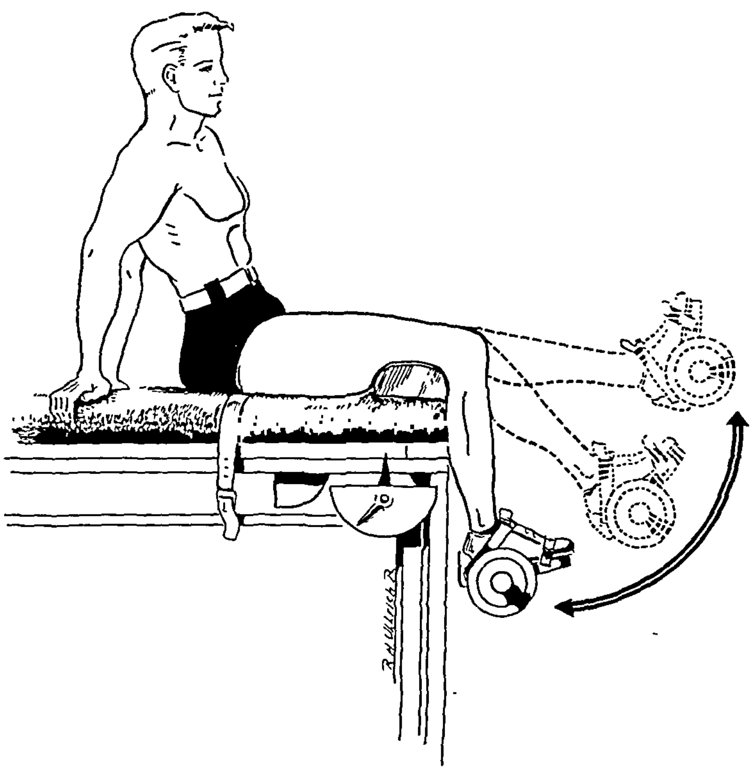


FIG. 1

Quadriceps femoris exercises employed for muscles of sufficient strength to extend completely against gravity.

Subjects of the Investigation

Nineteen subjects participated in this investigation, eight males and eleven females. Eight had bilateral involvement, and, therefore, comprised sixteen of the twenty-seven quadriceps studied. The interval between the end of the acute stage of the disease and the initiation of exercise ranged from one to forty-nine years; therefore, changes in muscle

* This study was aided by a grant from The National Foundation for Infantile Paralysis, Inc., New York, N. Y.

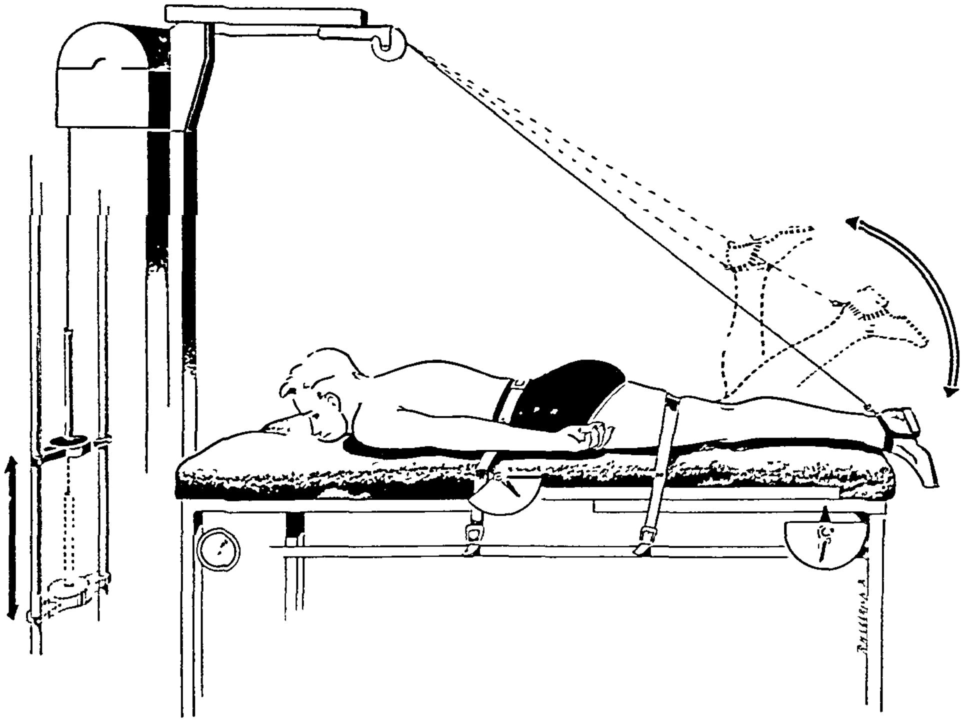


FIG. 2

Gravity-assisting exercise for extremely weak quadriceps femoris.

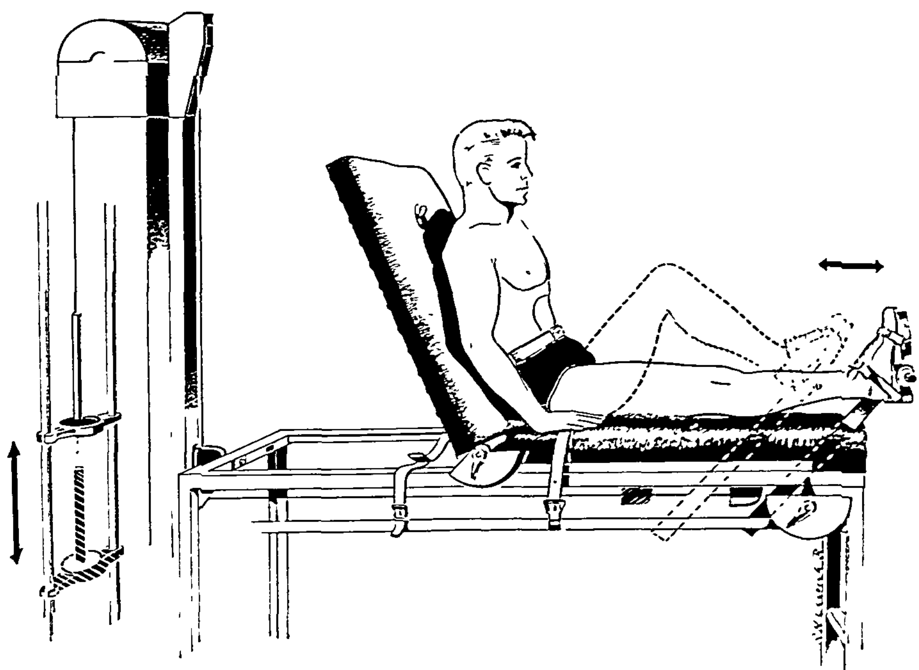


FIG. 3

Combined extension exercise for hip and knee.

function observed during the exercise period were probably due to exercise and not to spontaneous recovery. The ages of the participants ranged from eighteen to fifty years.

Originally, it was intended that all patients receive exercise for four months. However,

in only fourteen of the twenty-seven quadriceps femoris muscles studied, was the fou month period completed. Of the remaining thirteen in which the full course of exercise wa not completed, ten were accounted for because of financial, occupational, or transportatio difficulties of the patients. In the other three, strength equal to that of the uninvolved extremity (as measured by strength tests) was attained before the end of the four-month period. All subjects in this investigation exercised once daily, four days a week. One-repetition maximum and ten-repetition maximum were determined once a week [5,7].

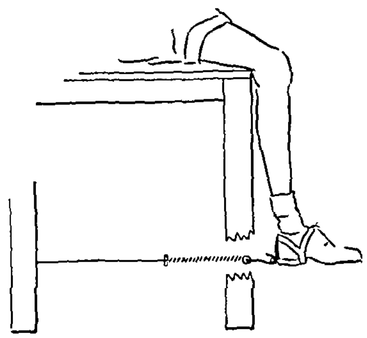


FIG. 4

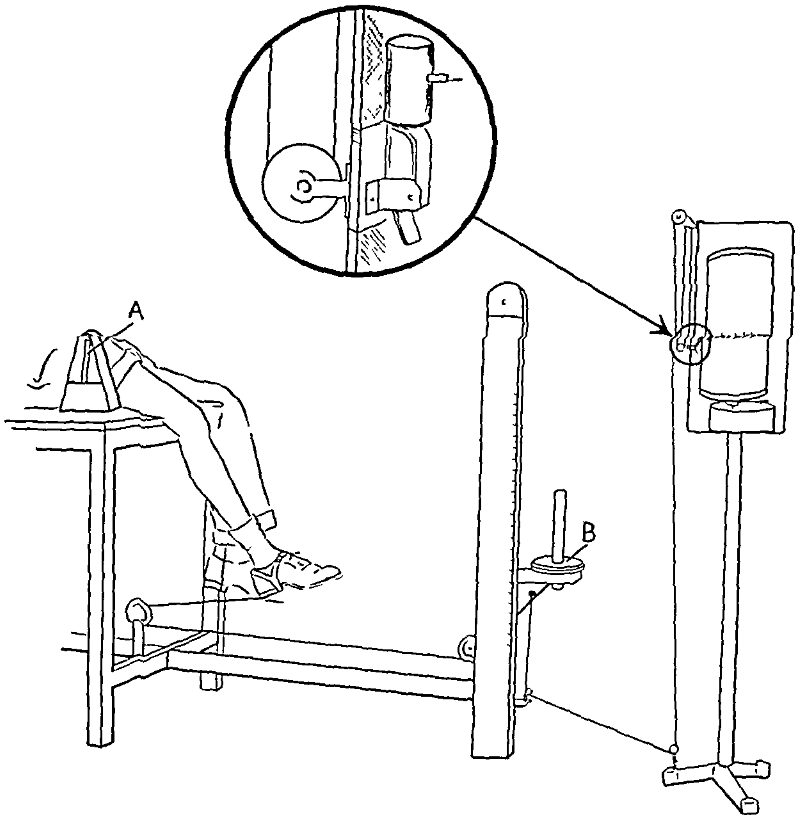


FIG. 5

Fig. 4: In the position shown, the patient is instructed to extend the leg with a maximum of effort The sitting position is maintained constantly, in order to prevent substitution and "trick" movements The highest of three readings is taken as representing the maximum quadriceps power in pounds.

Fig. 5: The ergograph shown is extremely simple and easy to construct. The drum and ink-writing pen were taken from an old basal-metabolism machine. The weight pan, *B*, is attached to the foot by means of a cable which operates over three pulleys. As the knee extends, the weight pan ascends. Knee extension is initiated from a position of 90 degrees of flexion. The thigh may be strapped to the table to prevent movement. A constant sitting position is maintained throughout the exercise period.

A string from the weight pan, *B*, passes over three pulleys and then through the pulley mounted on the pen (see inset). This arrangement reduces the excursion of the pen to one-half that of the weight pan.

By this technique the load to be lifted decreases as the knee extends, which for some purposes, already described, is undesirable. However, most activities, such as walking, stair-climbing, running, bicycling, or arising from a sitting position, are such that the quadriceps burden is reduced as the knee extends. Therefore, the ergographic technique employed is believed adequate for evaluations of work capacity of muscles operating under conditions present in everyday functional activity.

Throughout the period of investigation, the patients received no other remedial exercises, and they were instructed to continue daily activities as usual.

Methods of Evaluation

The progress resulting from exercise was evaluated at monthly intervals. Studies were made of: (1) muscle strength (maximum single effort); (2) work capacity; (3) limb volume; (4) electrical activity; and (5) functional ability. All tests on any one subject were scheduled at the same time of day, in an attempt to avoid diurnal variations.

1. *Maximum Muscle Strength:* Muscle strength was studied by two methods. One method of testing was by having the patient sit on a table, with his knee flexed at 90 degrees over the edge (Fig. 4). A spring scale was attached to the foot in this position, and the patient was instructed to exert a maximum amount of effort, the power, measured in pounds, being read directly from the scale. The other evaluation of strength was by the Lovett method of muscle grading.

2. *Work Capacity:* The work capacity in foot-pounds was measured with the ergograph (Fig. 5). The patient was not only familiarized with the ergograph, but was allowed to practise with light loads, and, for continuous motivation, was permitted to watch the ergograph throughout the exercise period. The following work conditions were standardized:

A. Speed of doing work (twenty-six repetitions per minute).
B. Rhythm of exercise (set by a metronome, giving an auditory and visual signal).
C. Load on muscle (sufficiently heavy to produce a sharp fatigue curve within one-half to two minutes).

By standardization of these conditions, the duration and extent of effort were the only remaining variables. Only one cycle of exercise was performed. The times occupied by relaxation and contraction were equal. As strength improved, the loads were kept constant. Improvement was thereby manifested by changes in conformation of the original fatigue curve.

The method of ergography employed here was not one in which the muscle load remained constant throughout the full arc of motion, as advocated by Hellebrandt and Skowlund. In our ergograph, the muscle load was greatest in the initial phase of the exercise and gradually decreased as the leg was carried into extention. Considered from the point of view of moments of force acting in this arrangement, the exercise should have become easier as the knee was extended. However, this did not prove to be entirely true; with the onset of fatigue, the height to which the weight could be raised gradually decreased. Thus the decreasing mechanical advantage of the pull of the weight was probably offset to some extent by changes in effective lifting tension. present in different phases of the arc of motion, thereby making the exercise more difficult. Since the purpose of the ergographic studies was chiefly to help evaluate the functional improvement, and not for accurate determination of work capacity, which involves rigid standardization of measurement, it was felt that the technique employed here was acceptable.

3. *Limb Volume:* A simple and effective method for studying limb volume was devised by one of the authors (R.S.S.). The method is illustrated in Figure 6, and consisted

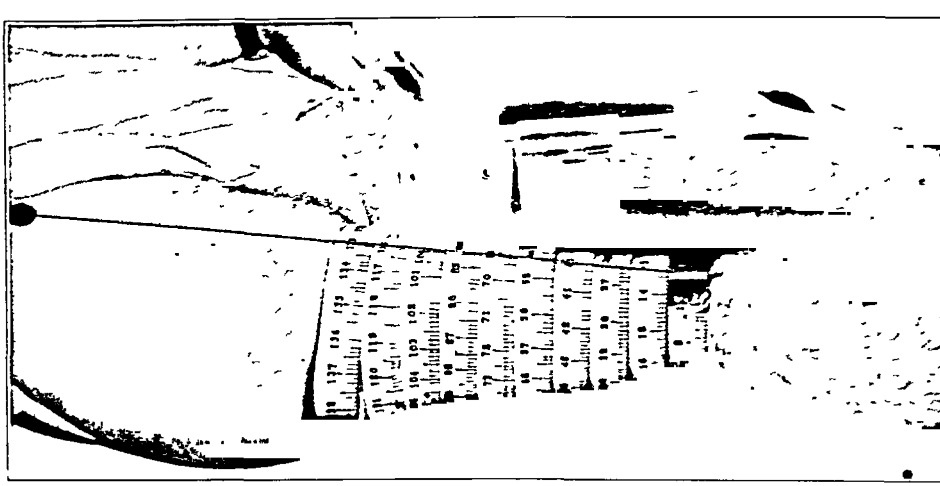


FIG. 6

The tape is applied in the manner illustrated. A string is then extended from the anterior superior spine to an ink dot on the mid-point of the suprapatellar border. At each intersection of the string and tape a reading (in inches) is taken. By subtracting the reading from the one above it, a series of circumferences are obtained. These are plotted in graphic form, as shown in Chart I.

In true circumferential measurements, the helix must be corrected for; however, in comparative studies, this is unnecessary.

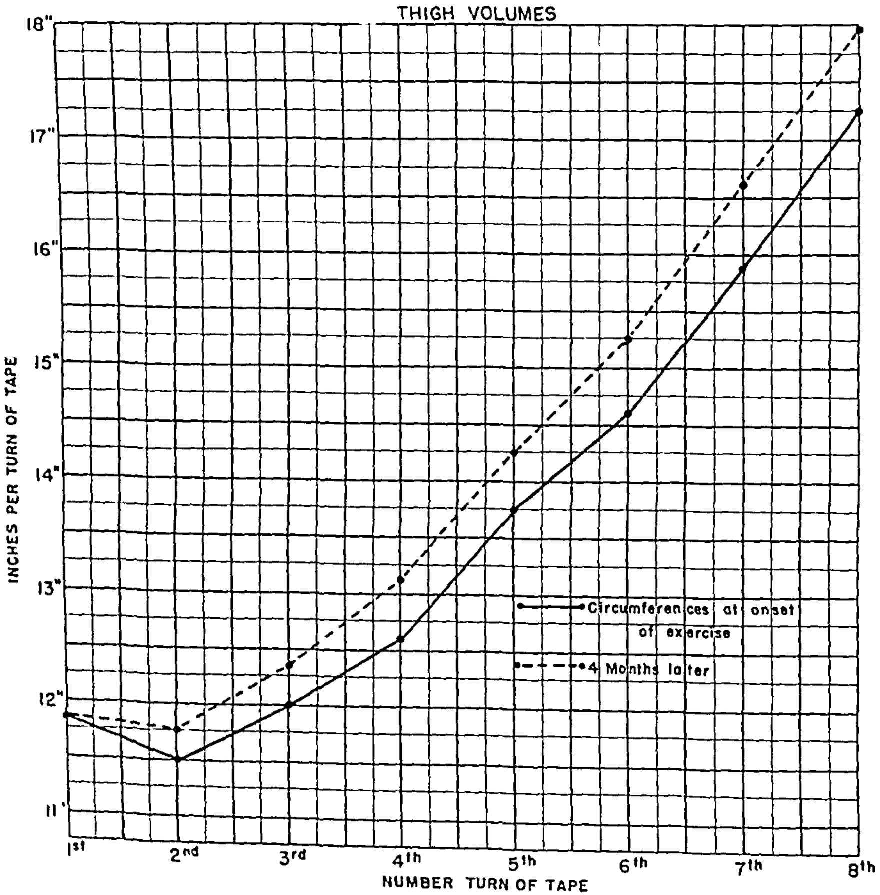


CHART I

QUADRICEPS NUMBER	INTERVAL IN YEARS	TIME ON EXERCISE IN MONTHS	LOVETT GRADE BEFORE	LOVETT GRADE AFTER	POWER IN LBS. BEFORE	POWER IN LBS. AFTER	WORK CAP. FOOT LBS. BEF.	WORK CAP. FOOT LBS. AFT.
1	1	4	G	G+	17 1/2	50	178	281
2	1	4	F	F+	2 1/2	8 1/2	7.2	20
3	20	4	G+	N	38	50	251	541
4	20	3	P+	P+	3	16	1.1	12
5	1 1/4	3	G	G	15	25	177	298
6	1 5/6	1	F+	G-	7 1/2	12 1/2	95	207
7	16	4	G-	G+	30	50	344	451
8	22	1	G-	G	46	52	554	1247
9	31	4	P+	P+	9 1/2	15	6	30
10	1 1/2	4	P+	P+	1/2	3 1/2	.1	3
11	1 1/2	4	P	P+	1/2	4 1/2	.7	5
12	34	2 1/2	G-	G+	7 1/2	40	435	408
13	1 1/4	4	F+	F+	2 1/2	9	21	41+
14	1 1/2	4	F+	G	7 1/2	24	21	390
15	1 1/2	3	N	N	70	86	554	868
16	49	3	G-	G	9	18	31	54
17	26	2	F+	G-	21	24	150	297
18	26	2	G	N	35	100	836	740
19	2 1/2	2	G	N	17 1/2	80	380	1376
20	2 1/2	2	N	N	42 1/2	85	896	2035
21	1 1/4	4	G	G	5	20	59	236
22	1 1/4	4	N	N	27 1/2	60	536	530
23	7	4	P+	F-	2 1/2	12 1/2	34	73+
24	1 1/2	4	P	P+	1/4	2	33	51
25	1 1/2	4	P	P+	1/2	3	2.4	12
26	1 1/2	1	G	G+	25	32	121	267
27	1 1/2	1	G-	G	20	30	111	178

CHART II

Chart I: Graphic representation of circumferential measurements.

Chart II: Chart shows progress made by the twenty-seven quadriceps muscles. The column, "Interval in Years", refers to the time between the acute attack of poliomyelitis and the beginning of this investigation. Three of the quadriceps femoris muscles were graded as "normal" before exercise therapy was begun. These were included in the investigation for, although they did have "normal" manual grades, they were either below normal as compared to quadriceps muscles in individuals of the same age and weight, or they did not possess the same strength as the uninvolved quadriceps femoris.

G = Good. F = Fair. P = Poor. N = Normal

essentially in winding a one-inch tape spirally about the extremity with the edges immediately adjacent. A string was placed at a right angle to the tape, and readings were taken at the intersection of the string and the tape. From these readings, the volume of the limb covered by the tape could be calculated in cubic centimeters, or the circumference per turn of tape could be plotted graphically (Chart I). By careful application of the tape, the maximum circumferential variation was reduced to one-quarter of an inch. For showing changes in thigh volume in this investigation, the latter method was chosen.

4. *Electrical Activity:* Records were obtained, from standard positions on the quadriceps, with paired surface electrodes leading into an ink-writing oscillograph. Spontaneous discharges from resting muscles, effects of passive stretching, and patterns of active potentials on active motion against maximum resistances were studied. The total voltage output was roughly quantitated by means of an integrator, according to methods previously described by Schwab, Watkins, and Brazier. Samples were taken before exercise therapy and at monthly intervals during treatment.

5. *Functional Ability:* At the end of the exercise program, subjective and objective signs of improvement were recorded,—that is, in gait, fatigue, stair-climbing ability, et cetera.

RESULTS

Muscle Power

The inadequacies of the Lovett manual method of muscle grading for evaluating true muscle power are well recognized. However, it was felt that such a test would be of clinical interest, in view of its widespread use. Therefore, all Lovett grades were given by the same technician, without access to the previous grading. Lovett grading was done only before and after exercise; therefore, monthly grades were not recorded. The technique of testing corresponded to that described by Daniels, Williams, and Worthingham.

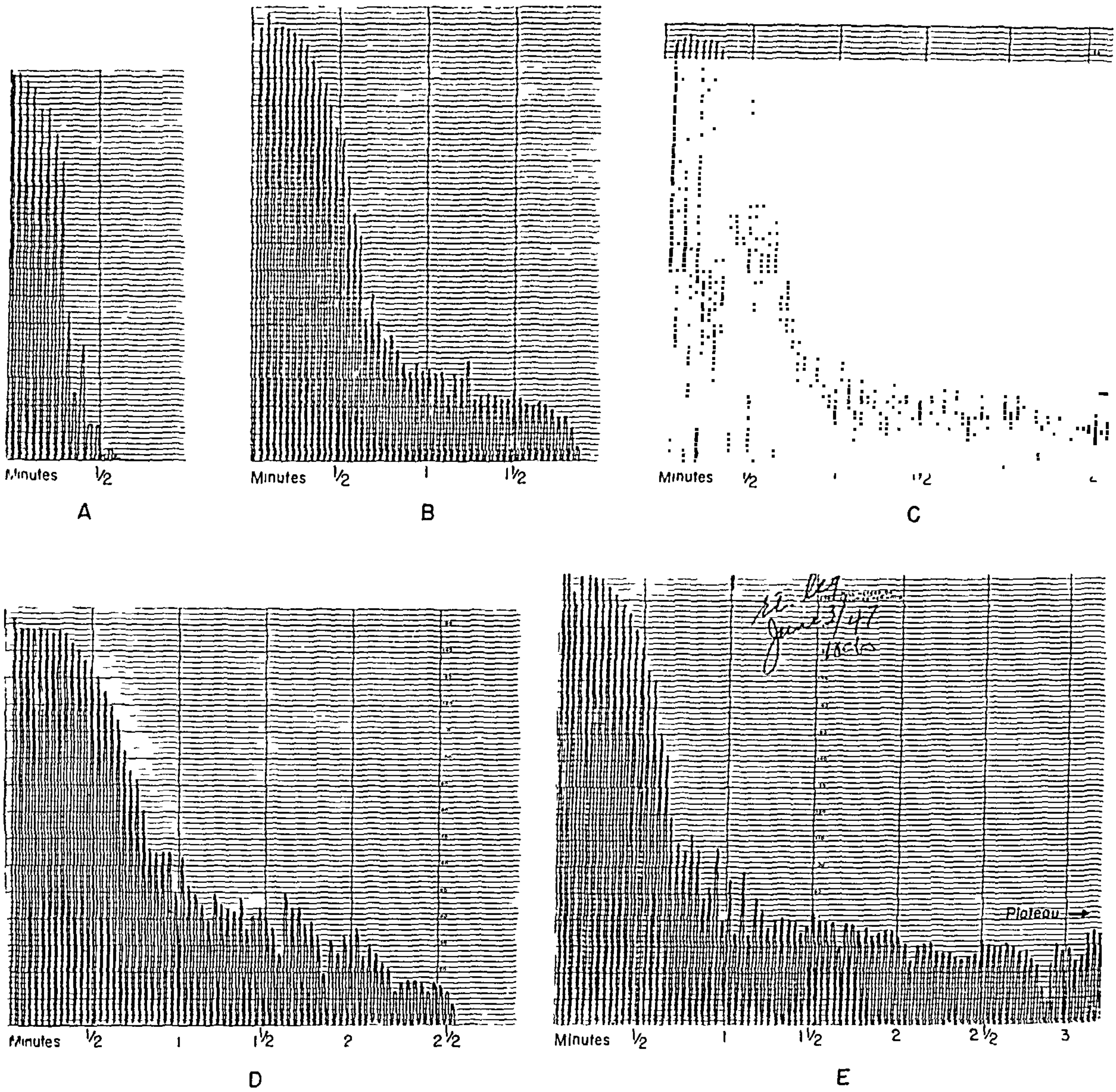
Of the twenty-seven muscles, seventeen were graded higher after one to four months of exercise. Ten of the seventeen were rated higher within the grade. The other seven were placed in the next higher grade. This would be significant when, for example, a "poor" muscle, which was unable to operate against gravity, regained enough power to be graded "fair", or when a "good" muscle became as strong as the uninvolved muscle and was thus rated "normal".

"Poor" (poor minus to poor plus) muscles in this investigation had strength, as measured with the spring scale, varying from one-half to sixteen pounds. "Fair" muscles varied from two and one-half to twenty-one pounds. "Good" muscles varied from five to fifty-two pounds, and "normal" grades varied from twenty-seven to one hundred pounds. This clearly demonstrates the unreliability of manual grading as a quantitative method of evaluating muscle power. Some authors, including Nicoll, have expressed the belief that different components of the quadriceps femoris function at varying intensities in different portions of the arc of motion. In the case of the quadriceps femoris, this helps to explain such wide variations in power in a muscle of the same clinical grade. For example, if the vastus medialis functions chiefly through the last few degrees of extension, and the patient had a very weak vastus medialis but fair power in the remaining components, then by the spring-scale test, the quadriceps would show relatively more power with the knee flexed to 90 degrees than when in complete extension.

Too much dependence must not be placed in the manual method of grading muscle power in quantitative evaluations of results of exercise. For example, the left quadriceps of an ice skater, fifteen months after an acute attack of anterior poliomyelitis, was rated "normal" and possessed eighty-five pounds of power. The right quadriceps was rated "good" with fifteen pounds of power. After exercise, the right quadriceps power had increased to thirty-five pounds, but could still be rated only as "good".

This method of grading muscle power should be used cautiously, especially when

QUADRICEPS No. 21



QUADRICEPS No. 22

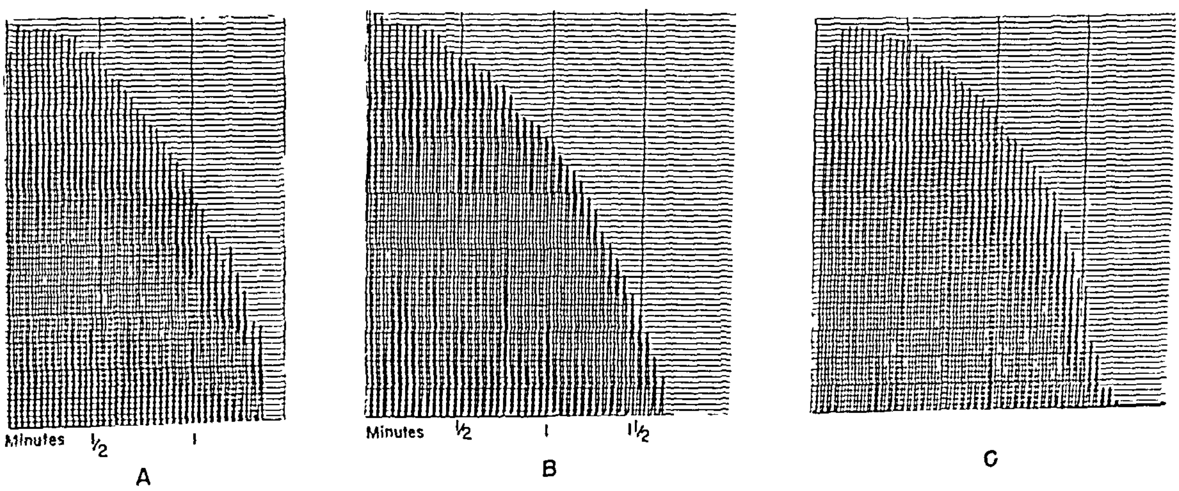


Chart III

Quadriceps No. 21: *A*, *B*, and *D* show fatigue curves. *C* and *E* show fatigue levels. Note that *E* is a higher level than *C*.

Quadriceps No. 22: Three fatigue curves from the same muscle, showing the highly characteristic nature of the ergograms for the subject.

evaluation is done with a view to surgery or to planning more conservative treatment. One "poor" quadriceps might be increased to "fair" and give a fairly strong knee, thus making a brace unnecessary, while the power of another "poor" muscle would never increase sufficiently to stabilize a knee. A more quantitative method of measuring power would have pointed this out.

Likewise, too much importance should not be attached to manual grading of power in muscles being considered for transplantation. They should be thoroughly checked for power, and consideration should be given to what the effective power of the muscle would be after transplantation. Because of an excellent mechanical advantage, a relatively weak muscle can appear strong. When transplanted and forced to pull at a disadvantage, its effective power may not be sufficient to assume the function intended for it. It would seem a wise policy to develop maximum power in the muscle before transplantation. On several occasions the strength of a hamstring has been doubled before transplantation, to supplement the power of the quadriceps.

A spring scale for measuring muscle power (Fig. 4) was used in place of determining the one-repetition maximum as previously described, since this method, although good for fairly strong muscles, is not satisfactory for muscles too weak to extend completely against gravity. Power studies for a similar investigation, recently initiated, will be performed with the use of the electronic myodynemeter, as developed by Dr. W. C. Beasley of the United States Public Health Service. This will permit studies of power at any point in the arc of motion.

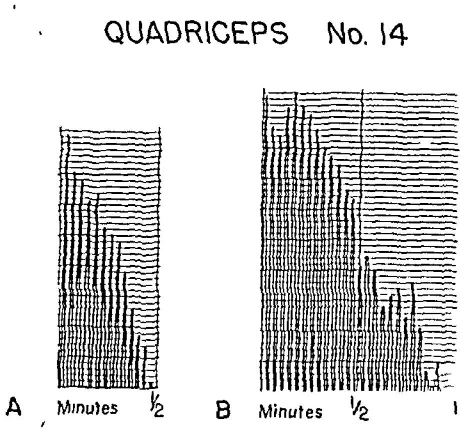
The power of normal muscles can be doubled in the first four to six weeks of exercise[6,13]. Of the twenty-seven quadriceps muscles studied, fifteen doubled or more than doubled quadriceps power in the first month (Chart II). The remaining twelve showed improvement, ranging from 1 per cent. to 89 per cent. These results are believed to compare favorably with the response of normal muscles.

The authors' data support Hellebrandt, Parrish, and Houtz in the belief that the single-effort test of strength cannot be used as a criterion of the functional capacity of skeletal muscle. Ergograms *A*, *B*, and *C* of Quadriceps No. 22 (Chart III) show almost negligible improvement in work capacity; however, the power during the two-month period increased 49 per cent. Others have shown an actual decrease in work capacity with a large increase in muscle strength. The reasons for these apparent discrepancies are too numerous and complicated to be discussed here, but they involve the technical difficulty in measuring work capacity and muscle power, the physiological properties of muscle action, the will to put forth a maximum effort and to endure for the duration of the ergographic test the discomfort of repetitive all-out effort, et cetera. These observations, however, do not invalidate the ergographic and strength tests as worth-while clinical tests for judging the responses to exercise therapy. Improvements in technique, control of technical difficulties, and proper instruction and encouragement of the patient render them most effective tests for the study of muscle function.

Lombard, in 1892, while studying some of the influences which affect the power of voluntary muscle contractions, noted that immediately after the beginning of a strenuous exercise regimen, muscle power decreased sharply; and it was nearly a week before power returned to the initial level. The authors have noted the same phenomenon in the care of patients with both immobilization atrophy and poliomyelitis. It may well be that this initial steady decline in strength during strenuous exercise prompted the belief held by some investigators that strenuous exercise produces ill effects in severely weakened muscles[1]. In the experience of the authors, both normal and atrophied muscles will recover this loss and will eventually surpass their initial power.

Accurate determinations of maximum potential muscle power by the methods described, or by any other method known to the authors, are impossible. Certainly, all of the gains recorded in muscle strength cannot be accounted for by anatomical changes within

the muscle itself. The element of learning plays an important part, even in the performance of extremely simple motor acts, and probably contributes in no small way to the increased ability to exert a maximum effort. At the time of initiation of exercise therapy, the influence of learning is lowest; and strength measurements taken at this time often reveal considerably lower values than measurements taken a few days later. This rapid improvement in effective strength occurs before any gross changes in muscle volume are noticed, and is due largely to motor learning. The patient's concept of maximum exertion and his willingness to endure the discomfort of maximum exertion may also account for rapid increases in effective strength. All factors considered, however, the strength measurements are indicative of the effective lifting power at that moment and under the existing conditions.



Work Capacity

All except three muscles showed an over-all increase in work capacity. The improvement in functional capacity of the remainder was manifested ergographically in two ways: first, by an increase in height of contraction and, second, by an increase in the number of contractions. As previously stated, the initial ergographic studies were carried out with weights that produced a sharp fatigue curve in from one-half to two minutes. On subsequent tests, as strength increased, this weight was not increased, as is advocated by some

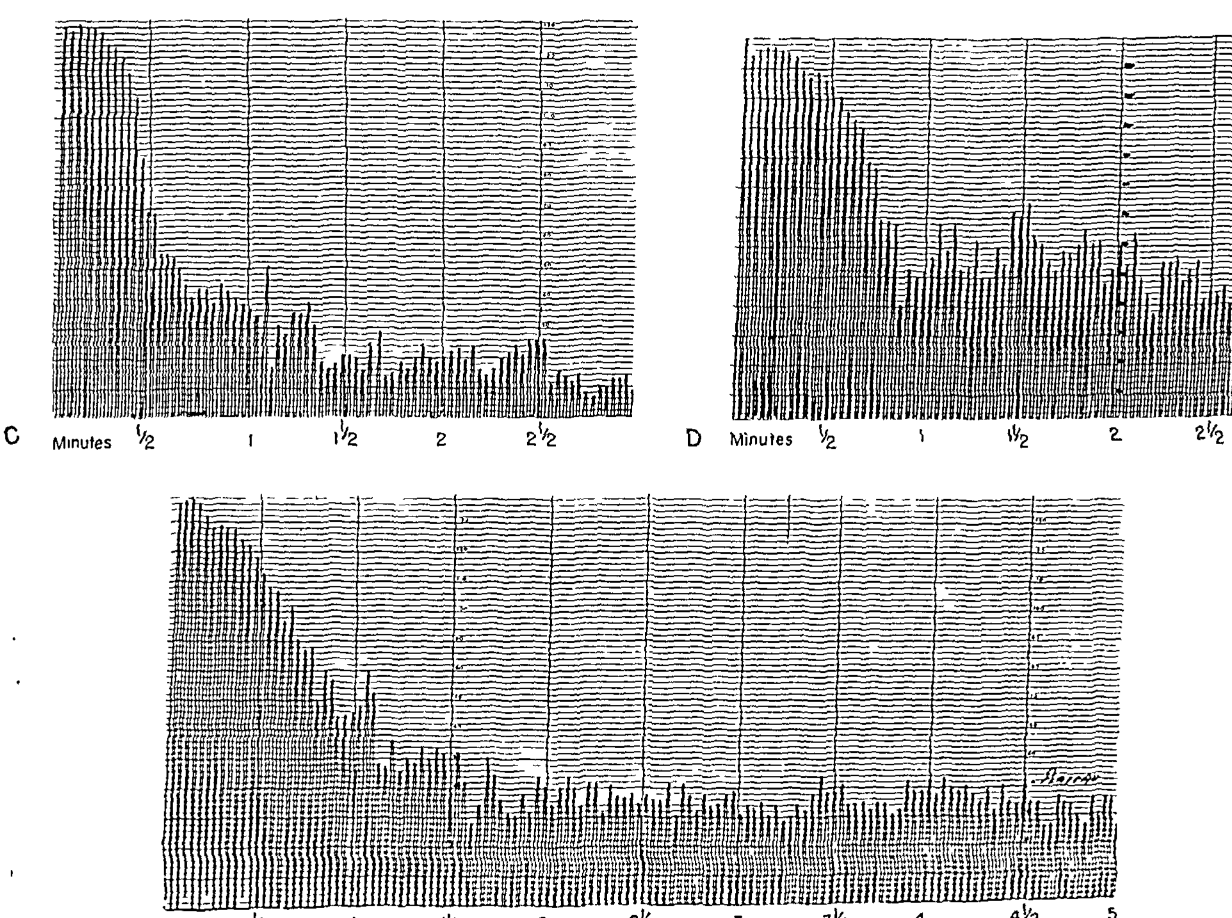


CHART IV

Fatigue curves shown in *A*, *B*, and *D*; *C* and *E* are fatigue levels. The fatigue level, *E*, is much higher than *C*.

investigators. Instead, improvement in performance with the same weight was studied. The typical response is illustrated by ergograms *A*, *B*, and *C* of Quadriceps No. 21 (Chart III). As strength increased, the height and number of possible contractions increased, until eventually the fatigue curve was replaced by a fatigue level. Weights, so heavy that with maximum exertion they can be lifted only a few times, produce rapid and complete fatigue; and the ergographic manifestation of such a performance is called a fatigue curve (Chart IV, *A* and *B*). However, with lighter weights, highly repetitive performance is possible; and although due to fatigue, the original height of contraction cannot be maintained, contractions to a lower level may be continued indefinitely. Here the ergogram shows the fatigue curve approaching its asymptote, *C* and *E* (Chart IV), and the height to which the weight can be lifted remains constant indefinitely. This plateau of muscle activity represents aerobic contractions and manifests itself ergographically by a fatigue level. The monthly measurements of work capacity are recorded in Chart II.

The work capacity of eleven of the twenty-seven quadriceps muscles had at least doubled after one month of exercise. Fifteen of the twenty-seven doubled their maximum strength in one month. Of this fifteen, only eight were among those whose work capacity doubled in the same four-week period. Of the eleven whose work capacity doubled, eight were among those who had a twofold increase in power. None of the muscles showed a permanent reduction in power; however, slight increases in power were frequently accompanied by a great increase in work capacity and, conversely, large increments in muscle strength were occasionally accompanied by a decrease in work capacity. Such observations make imperative the individual consideration of data to obtain accurate information as to the functional changes in muscle activity.

Patients whose quadriceps could not function against gravity (one-half to sixteen pounds of power) did not, as a rule, regain complete extension. However, in all subjects, the height and duration of contractions increased, as shown ergographically (Chart V, Quadriceps No. 4, *A*, *B*, and *C*). The patients stated that these muscles became fatigued less readily and that they had better control of them. This almost uniform response is at least a partial answer to the question of whether or not it is worth while to develop the power of such extremely weak muscles. A patient with severe involvement, two years after the acute phase of anterior poliomyelitis, had only four muscles that could operate against gravity, with the exception of the muscles of the fingers and leg, the remainder being rated "poor plus" or below. Consequently, the patient was unable to walk even with crutches. After one and one-half years of progressive-resistance exercise, the patient was able to walk with the aid of crutches for about 200 yards and could perform many activities, such as bathing and shaving, which had not been possible previous to exercise.

It may be generally stated that the degree of improvement in power and work capacity was approximately the same for extremely weak muscles as for muscles with greater initial strength, and that the failure to reach normal functional capacity was due to the absence of a normal number of motor units.

The ergographic data are in keeping with functional improvement observed by the patients,—namely: (1) less difficulty in performances requiring strength, and (2) ability to perform for longer periods without fatigue.

The ergograms reflect the susceptibility of the subject to fatigue, and are highly characteristic for each subject. Ergograms *A*, *B*, and *C*, of Quadriceps No. 22 (Chart III) illustrate the striking similarity in repeated monthly performances. Quadriceps No. 21 is of the same subject as Quadriceps No. 22 and also demonstrates its own characteristic curve, although of a different shape.

One interesting phenomenon was observed in these ergographic studies which, as far as we know, has not been described previously. It is illustrated by Quadriceps No. 1, *A*, *B*, *C*, and *D* (Chart V). Resistance was the same in all four ergographic tests. Before exercise, the weight quickly produced a fatigue curve, *A*. However, as strength increased, this was

replaced by a fatigue level, *C*. With further increases in strength, the fatigue level was replaced by a fatigue curve, *D*. This is probably due to the fact that, as power increased, the weight could be lifted higher, thereby greatly increasing the amount of work done in the initial contractions, rapidly fatiguing the muscle, and making repetitive effort impossible. Ergographic studies of Quadriceps No. 14 (Chart IV) and No. 21 (Chart III) illustrate a similar phenomenon, but, in addition, illustrate that with still further increases in strength, the fatigue curve was again displaced by a fatigue level. This new fatigue level, as would be expected, was considerably higher than the fatigue level first reached. Compare the heights of fatigue levels of *C* and *E* in Quadriceps No. 14 and No. 21 (Charts IV and III, respectively).

Limb Volume

The errors introduced by the method employed in this study for measuring changes in muscle volume are too numerous and too obvious to warrant discussion. Even if it were possible accurately to measure muscle-volume changes, it still would be extremely difficult to say how much of the strength increase was due to hypertrophy and how much was due to innate and acquired skill, modification of the concept of maximum exertion, et cetera. Nevertheless, eighteen of the twenty-seven thighs were measured by this method before and after exercise, for gross changes in limb circumference over the area occupied by the quadriceps femoris. Since the maximum variation in circumferential measurement, by the spiral-tape method, was one-quarter of an inch, changes smaller than this were disregarded. For eight of the eighteen, a substantial increase in thigh circumference was registered. These eight, without exception, were muscles of good strength initially, and after exercise they developed nearly normal power. None of the severely involved subjects showed an increase in thigh circumference. Assuming that the increases in circumference were indicative of an increase in muscle volume, these observations would be in accordance with the working hypothesis set forth earlier in the paper. The volume increase produced by a few hypertrophied fibers would not, of course, equal that produced by an equivalent degree of hypertrophy in a greater number of muscle fibers.

Houtz, Parrish, and Hellebrandt stated: "As the intelligently cooperative subject becomes enured to the discomfort invariably associated with the lifting of weights heavy enough to tax strength, the power to contract may extend so rapidly as to invalidate any hypothesis which attributes this phenomenon to morphological change in the contractile elements which compose muscle". While the authors agree that the most important element in increasing power and work output is the willingness to put forth a maximum effort, it is difficult to imagine such great increments in strength being unaccompanied by modifications in the muscle structure itself.

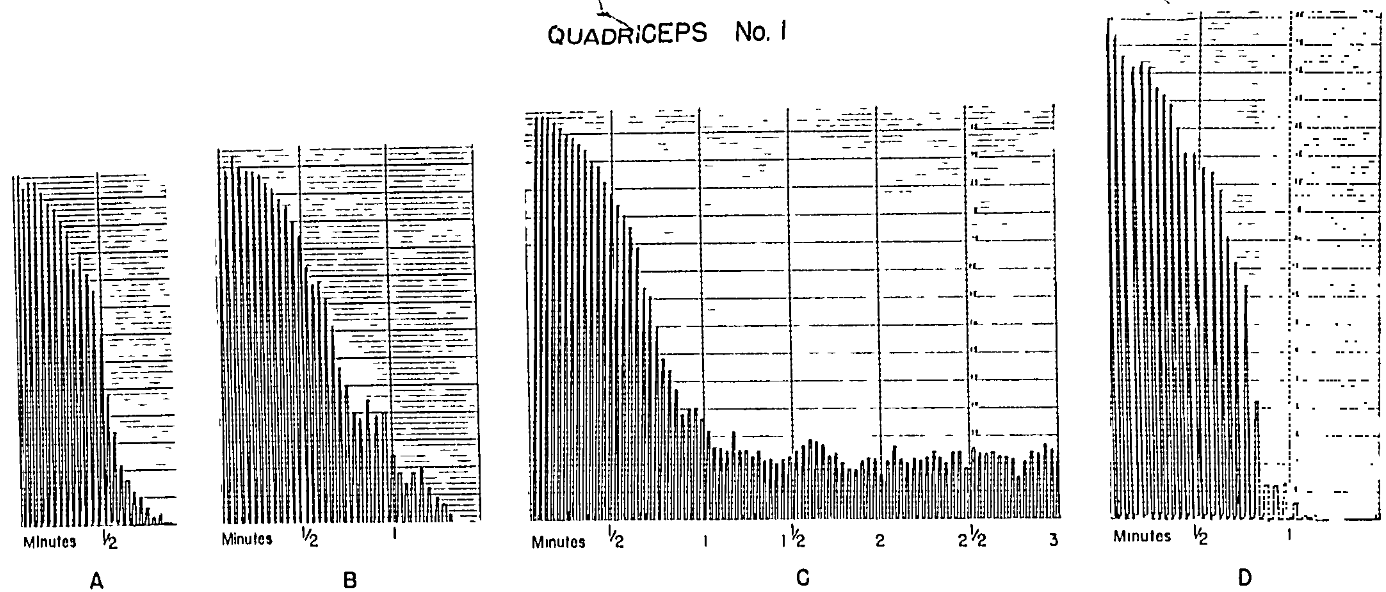
Electrical Activity

The electromyographic records showed that, in these cases of long-standing poliomyelitis with considerable residual weakness, there was usually a slight amount of resting activity in the form of single diphasic high-voltage spikes. In about 50 per cent. of the cases, the number of spontaneous discharges apparently increased with exercise therapy.

The action potentials during maximum voluntary contraction against resistance showed some increase in voltage, as judged by inspection and the discharges totaled by the integrator. This method is not considered of great quantitative accuracy; but the results showed improvement in the pattern of electrical activity, consistent with the clinical improvement in power.

Functional Ability

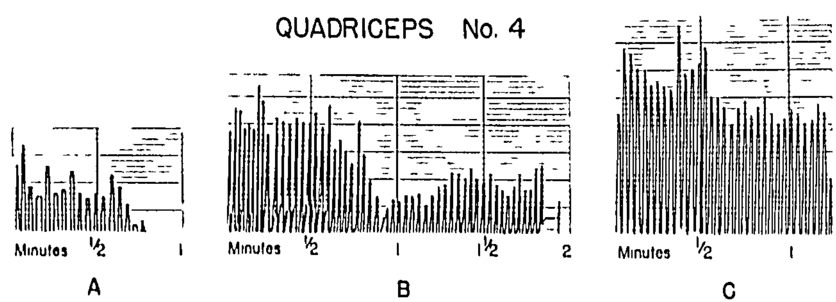
The improvement reported most frequently by patients was the ability to perform ordinary activities with less effort and fatigue. Other improvements reported were numer-



Quadriceps No. 1: With increases in strength, fatigue curves *A* and *B* are replaced by fatigue level, *C*, which, in turn, is replaced by a fatigue curve, *D*, with further strength gains.

Quadriceps No. 4: Ergograms of an extremely weak quadriceps. The fatigue curve, *A*, is replaced by fatigue levels, *B* and *C*, as strength increases. The level of *C* is higher than *B*. Although complete knee extension was never possible, the strength increases were manifested by successively higher fatigue levels.

Quadriceps No. 7: Highly characteristic ergograms for Quadriceps No. 7. This subject showed relatively small gains in work capacity (20 per cent.), although strength increased 67 per cent.



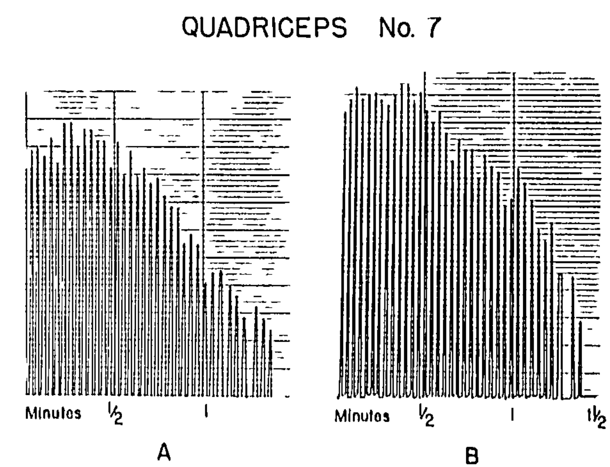


CHART V

ous and varied; for example, a professional ice-skater regained sufficient quadriceps strength to execute difficult leaps with the involved extremity without buckling of the knee. A carpenter regained normal stair-climbing ability and was able to resume his former work, which required standing all day. Two patients discarded crutches upon which they had depended since their initial attacks, one and seven years before. A high-school student with severe involvement, who had been confined to a wheel chair for one and one-half years, acquired sufficient power to walk about 200 yards with crutches and to perform many everyday activities which had formerly been impossible.

Three patients noted no improvement in functional ability as a result of exercise. They represented four of the quadriceps muscles studied, and had displayed no symptoms due to quadriceps weakness prior to exercise. Although these three had good quadriceps power before exercise, the strength of the involved extremity was considerably less than normal. However, since it was the purpose of the investigation to study the response of all degrees of involvement, these patients were included.

One patient in this series has received progressive-resistance exercises for fifteen months and continues to show small, but definite, gains in strength. Several continued this exercise regimen after the close of the investigation and made further progress. Although the time required for the development of maximum power in the normal muscle is not known, professional-strength athletes feel that approximately four years of hard work are required to achieve maximum muscle development. This estimate, however crude, bears one significant therapeutic implication,—that it requires many months, and probably years, for maximum power to develop in a normal muscle. Evidence so far indicates that this is true for poliomyelitic patients and emphasizes the necessity for an extended program of exercise. Poliomyelitic patients with severe involvement, who cannot be offered increased functional strength by surgery, have no alternative but to attempt to develop the residual muscle power. Since maximum strength must be maintained, it is necessary for both physician and patient to realize that remedial exercise must be continued permanently and that adequate provisions must be made for carrying out the routine.

SUMMARY

The qualitative and quantitative evidence presented supports the hypothesis that, following acute anterior poliomyelitis, the remaining innervated muscles respond to progressive-resistance exercises by an increase in strength and work capacity in much the same manner as normal muscles.

NOTE: The authors are indebted to Miss Mary Nesbitt for doing all the Lovett muscle tests, and for rendering valuable assistance in many other ways.

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The Future of Orthopaedic Surgery

BY ROBERT I. HARRIS, M.B.

(Continued from page 810)

influence our training of the young men who are to follow us. They must be sufficiently familiar with the basic sciences to appreciate the merits of new work, and to share in any research in which this knowledge is applied to the problems of clinical orthopaedics. They must also be experienced in the basic problems of surgery. This frequently is referred to as a period of training in *general surgery*. We must define "general surgery" before we can accept it as an essential part of the training of an orthopaedic surgeon. In the modern usage of the term, it means too often visceral surgery, and there is some doubt as to how much this contributes to the training of an orthopaedic surgeon. What he *does* require is adequate knowledge of problems which are basic in all fields of surgery,—the diagnosis of disease, inflammation, the control of infection, repair of wounds, fluid balance, shock, anoxia, and fractures. In addition, he must have a working knowledge of the fundamental sciences.

The future of orthopaedic surgery will be intimately concerned with the broadening of our knowledge of the structure and function of the tissues with which we deal. The approach will be through the basic sciences of anatomy, histology, biochemistry, physiology, and endocrinology. Operative orthopaedics will no longer occupy the center of the stage, although of necessity it will always be important to us, since it is the agent by which we conduct our therapy. There still will be advances in that field, refinements of technique, and new operations, but these means of advancing orthopaedic surgery will be overshadowed by the broadened knowledge of orthopaedic disease, which will come from research into the nature and structure of bone, cartilage, muscles, and connective tissues. The approach to our problems must be through the basic sciences, as well as through the techniques of operative surgery. This must influence our plan of training young men. We shall not retain mastery of our field, if we limit ourselves to operative therapy and depend upon others for the fundamental knowledge upon which rational therapy can be based.

RECONSTRUCTION OF A METACARPOPHALANGEAL JOINT WITH A METATARSAL TRANSPLANT *

BY WALTER C. GRAHAM, M.D., SANTA BARBARA, CALIFORNIA
AND DANIEL C. RIORDAN, M.D., NEW YORK, N. Y.

Some patients may sustain a considerable loss of the substance of a metacarpal bone as the result of injury, disease, or neoplastic invasion. All or part of the head, with its articulating surface, may be destroyed. If the diseased or damaged bone were lost or removed, the involved finger would become unstable, so that upon any attempt at flexion or extension the finger would merely telescope. Hence, some reconstruction of the joint

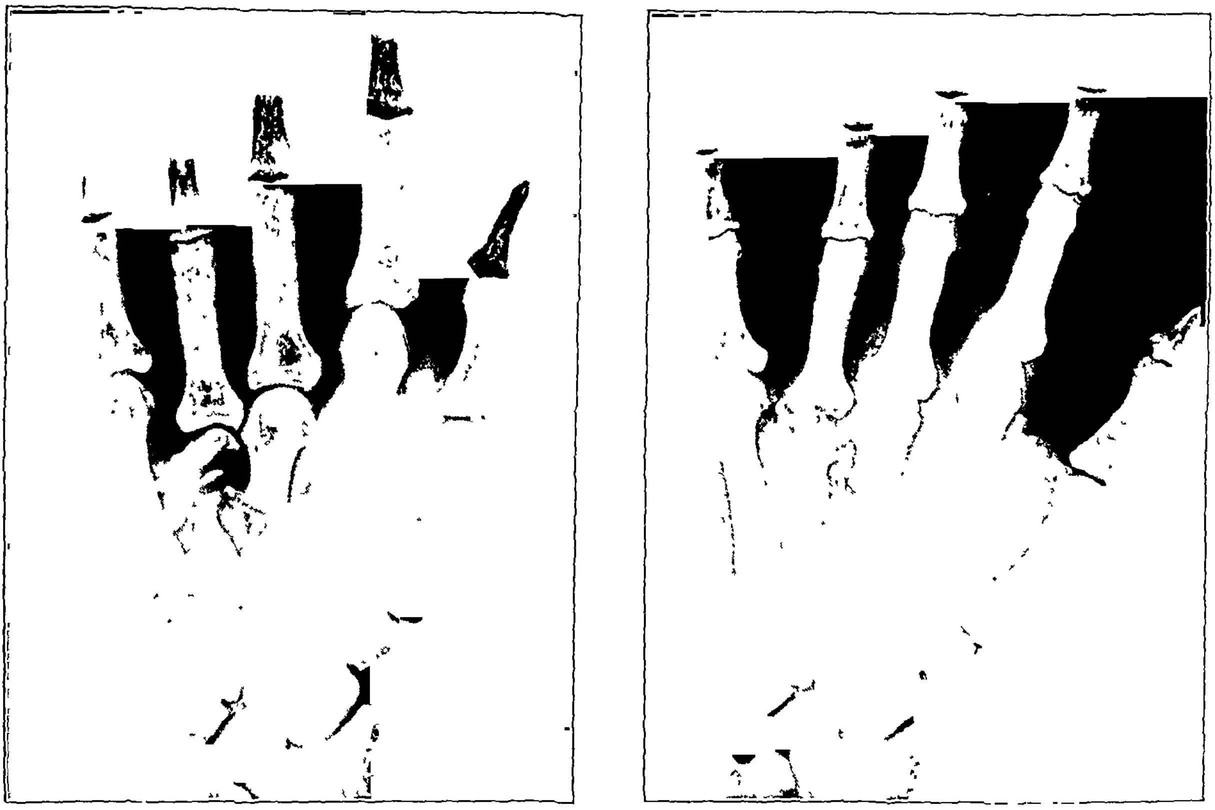

Fig. 1-A *Fig. 1-B*

Fig. 1-A: Case 1. Preoperative roentgenogram.
Fig. 1-B: Postoperative roentgenogram shows bone graft to third metacarpal and metatarsal transplant to fourth metacarpal.

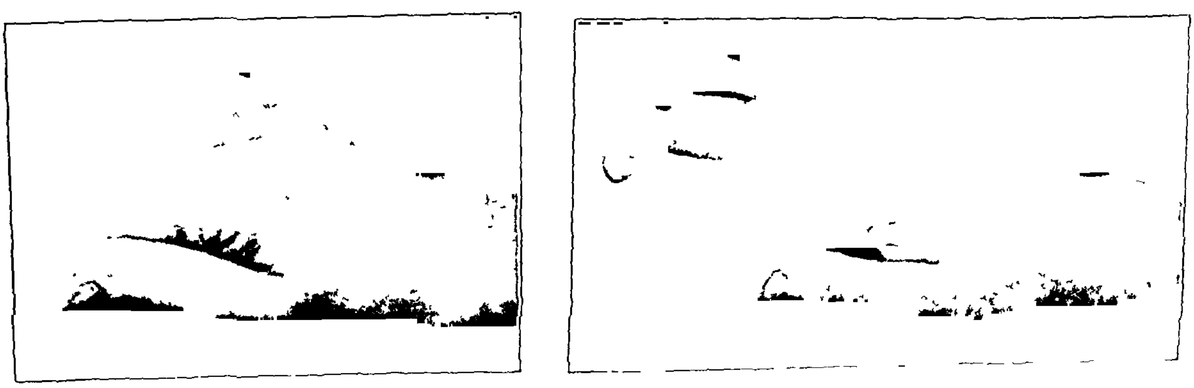

Fig. 1-C Fig. 1-D

Final photographs of fingers in flexion and extension.

* Read at the meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 23, 1948.

must be considered. A bone graft would be inadequate, because insufficient articular surface of the head can be salvaged to maintain a functional joint.

In such a patient, the articular surface of the proximal end of the proximal phalanx is normal. An adequate joint could be made if the distal surface of the metacarpal were intact. Because this is seldom the case, some bone with an articular surface must be selected as a transplant, so that a new joint can be made to simulate the original one. The only bone adaptable for transplantation, which would seem to meet the requirements of both stability and of providing an articular surface, is a metatarsal. Anatomically a metatarsal bone is not identical with a metacarpal, but it is sufficiently like it to form a gliding joint.

Fig. 2-A

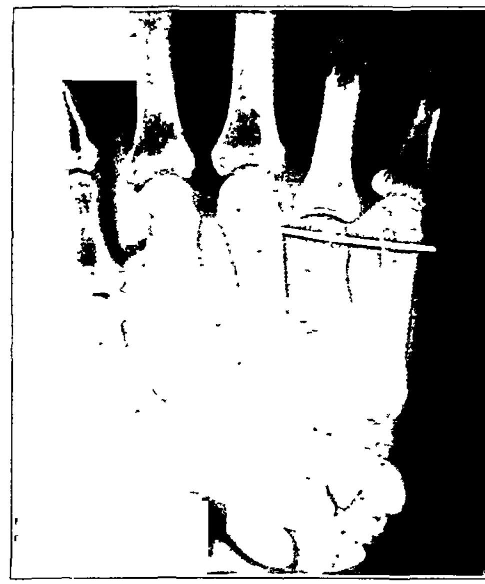

Fig. 2-B

Fig. 2-A: Case 2. Preliminary roentgenogram, showing defect.
Fig. 2-B: Postoperative roentgenogram.

Fig. 2-C

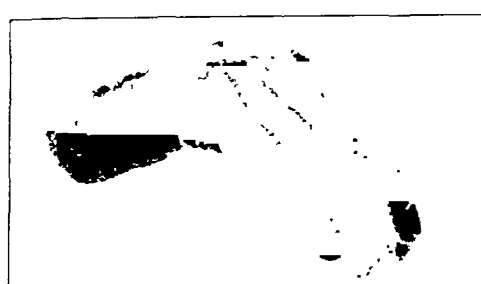

Fig. 2-D

Fig. 2-C: Final appearance of hand with fingers in extension.
Fig. 2-D: Final appearance with metacarpophalangeal joint in flexion.

Before a metatarsal transplant can be inserted into the hand, all scar and diseased tissue must be removed from the recipient site. This may require wide excision of local tissue, including bone, traumatized muscle, and other soft tissues. A large defect may result, which may require a remote flap in order to provide a sufficient amount of soft pliable tissue. The new joint will not function properly if any cicatricial tissue is left. The complete excision of scars is even more important in transplantations than in cases requiring arthroplasty, because with the transplant one is attempting to restore a gliding joint rather than substituting a hinged joint.

Removal of a portion of a metatarsal bone, including its head, might be objected to because of the possibility that crippling of the foot might ensue. Since the fourth and fifth metatarsals are functionally less important than the others, they seem to be more suitable for transplantation. The authors have used the fifth metatarsal in all but one case, because they believe that its removal causes less impairment to the foot than that of any other metatarsal. None of the patients have reported any symptoms in the foot from which this bone had been removed from eight months to two years before. In one case two metatarsals were transplanted; the fourth was taken from one foot and the fifth from the other (Figs. 4-A, 4-B, 4-C, and 4-D). This patient has had no discomfort in either foot as a result of the removal of these bones.

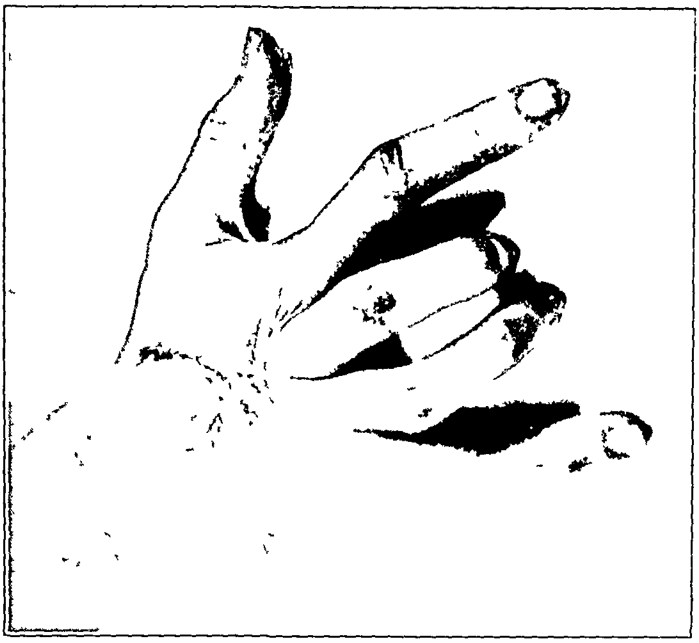

Fig. 3-A
Case 3. Preliminary photograph of hand

The operative technique of the procedure is relatively simple The diseased or damaged metacarpal should be removed, leavin the base and as much of the shaf as possible. None of the head o capsule should be left. The shaf of the metacarpal is cut in such manner that a close approximation with the transplanted meta tarsal will be possible. The meta tarsal is then fixed in place witl

Fig. 3-B
Preoperative roentgenograms.

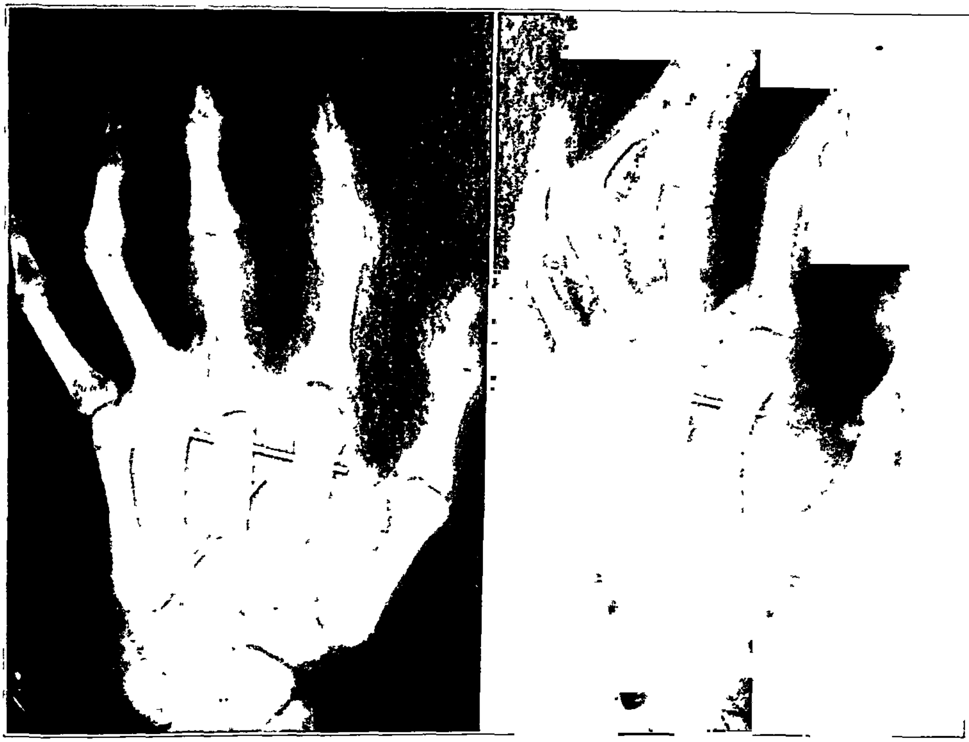

Fig. 3-C
Postoperative roentgenograms.

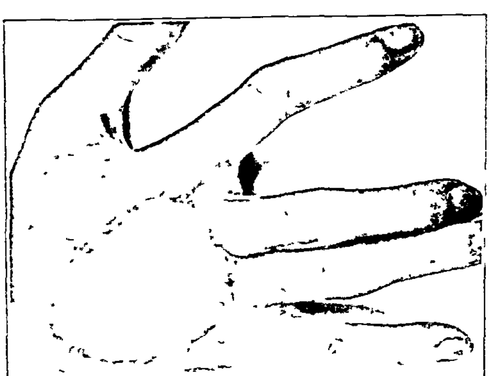

Fig. 3-D Fig. 3-E

Fig. 3-D: Final extension of hand after the application of a metatarsal transplant, abdominal flap, extensor-tendon graft, and sublimis transplant.
Fig. 3-E: Final appearance of hand in flexion.

Kirschner wires. One wire should be placed longitudinally and one or two others transversely, thus fixing the transplant to the adjacent metacarpals. It is also necessary to fix the extensor tendon firmly to the proximal end of the proximal phalanx, in order to prevent anterior subluxation of the phalanx. Finally, the exposed bone surface is covered with fat or other soft tissue in order to prevent adhesion of the extensor tendons. After the hand has been splinted in full extension for three weeks, active and passive mobilization is instituted. The postoperative mobility of the joint is greatly influenced by the condition of the intrinsic muscles. After the joint has been mobilized, a sublimis transplant may be necessary to replace the damaged intrinsic muscles. To secure a useful and functional joint, the restoration of intrinsic function is absolutely necessary. The method described by

Bunnell has proved entirely satisfactory. One technical difficulty encountered in these cases has been a tendency for the articular surface of the phalanx to become displaced anteriorly. This has usually been prevented by splinting the joint in complete extension and maintaining this position for three weeks. In some cases this tendency has been prevented by inserting Kirschner wires into the soft tissues posterior to the joint.

A tendency for the distal articular portion of the new joint to subluxate, laterally or medially, has been easily controlled by restoring the function of the intrinsic muscles. If this function is not restored, the finger will slide toward either the radial or the ulnar side. In the authors' first cases, an attempt was made to reconstruct collateral ligaments by transplanting the ligaments of the metatarsophalangeal joint, along with the bone. This practice was later abandoned, because it was found to be unnecessary and because excessive fibrous tissue tended to form. In the earlier cases, traction was applied in order to prevent pressure upon the articulation; this, however, also proved unnecessary.

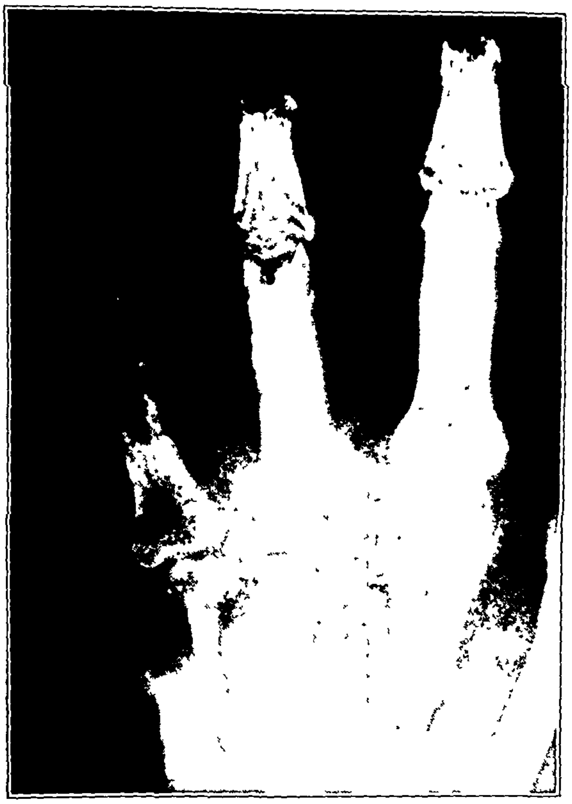

Fig. 4-A

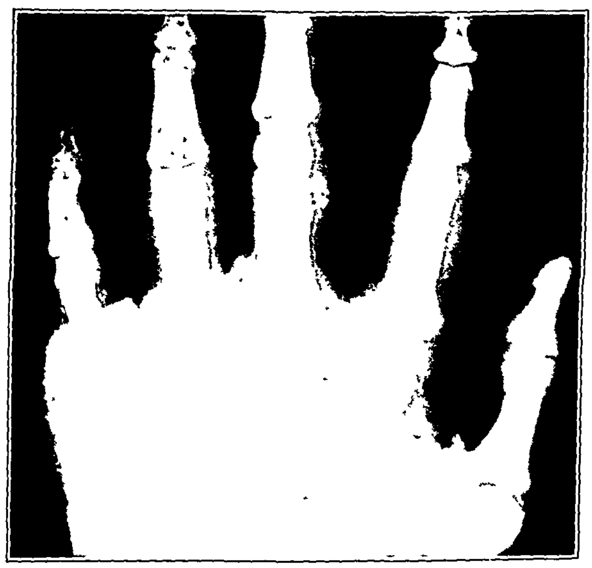

Fig. 4-B

Fig. 4-A: Case 4. Showing loss of heads of fourth and fifth metacarpals.

Fig. 4-B: Roentgenographic appearance after transplantation of the fourth metatarsal of one foot to replace the fourth metacarpal, and transplantation of the fifth metatarsal of the other foot to replace the fifth metacarpal.

Fig. 4-C

Fig. 4-D

Attempted flexion and extension of hand after reconstruction.

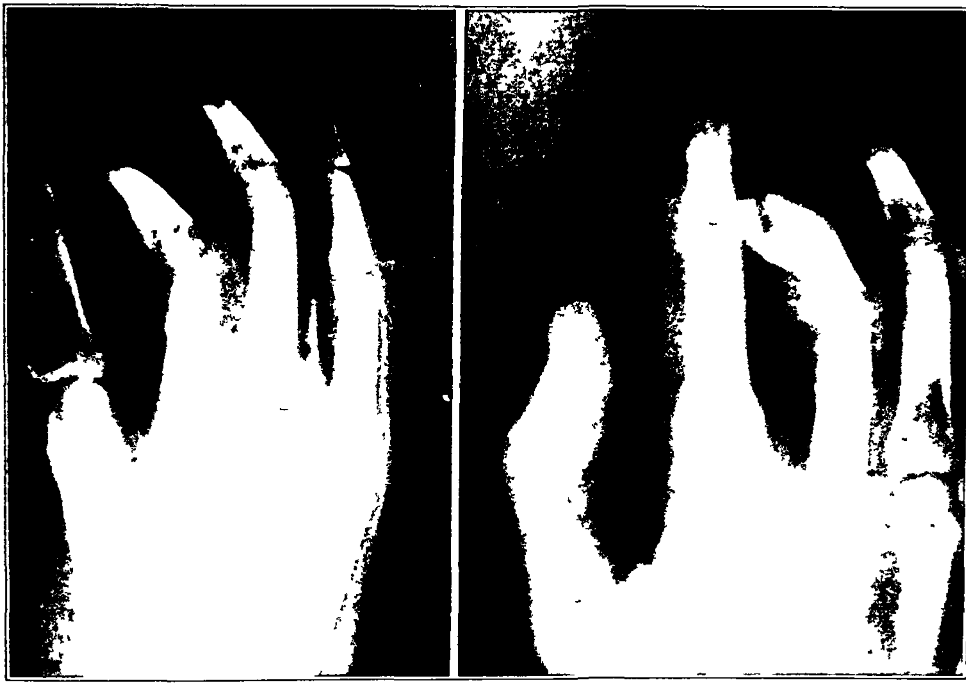

Fig 5-A
Case 5 Preliminary roentgenograms show loss of head of third metacarpal

Fig 5-B
Final roentgenograms showing the complication of anterior subluxation of the phalanx This could have been prevented by splinting the finger in full extension during the first three weeks

CONCLUSIONS

Experience has emphasized the importance (1) of completely excising all cicatricial tissue from the site which is to receive the transplant; (2) of re-establishing complete intrinsic-muscle control of the proximal and distal joints of the finger; and (3) of preventing anterior subluxation by reconstructing the extensor mechanism and by splinting the finger in complete extension during the period of immobilization

TRANSPLANTATION OF THE TIBIA AND FIBULA TO REPLACE THE FEMUR FOLLOWING RESECTION

"Turn-up-Plasty" of the Leg

BY C. P. VAN NES, M.D., LEIDEN, HOLLAND

From the Anna Clinic, University of Leiden, Leiden

The operation to be described is indicated when a total or nearly total resection of the femur appears to be necessary, as in some cases of tumor, osteomyelitis, or severe trauma. In these cases, we have only the choice between high amputation of the thigh or disarticulation of the hip. After these operations, we get a short stump, difficult to dress, which, even when equipped with a modern prosthesis, permits but an imperfect, awkward, and staggering gait. Most of these amputees walk with difficulty by the aid of canes or crutches. Their gait is in great contrast with that of the patient whose amputation was performed in the leg or at the knee. The latter patient, when provided with a good prosthesis, walks in an easy, well-balanced, nearly normal manner.

Because of this difference of gait, we wished to provide a long stump, descending to the level of the lower third of the thigh. In this way, we could render our patients a physical and psychological service,—physical, by giving them the chance to walk without difficulty and by reducing their incapacity to a great extent; psychological, by limiting the mutilation of their bodies to the minimum and restoring their ability to work. These factors are of great importance, for a patient accepts amputation of the leg or at the knee much more readily than amputation of the hip. The patient with an amputation at the hip considers himself extremely mutilated and disabled; he has great trouble in becoming content with his lot and in regaining his morale.

Starting with these ideas and feeling reluctant to sacrifice the healthy leg in cases of resection of the femur, the author has searched for a method which would allow preservation of the leg and its utilization for the construction of a long stump. This has resulted in the "turn-up-plasty", or the substitution for the femur of the leg on the same side. This method provides a stump of the same length as the resected portion of the femur. This stump, dressed in the same manner as that of a knee amputation, gave great satisfaction with regard to stability and locomotion.

The plastic method mentioned here was applied for the first time by Sauerbruch[1] more than twenty years ago. Although it was used later by other surgeons, for some unknown reason it did not enter into current practice. Probably it was judged too dangerous or too difficult from a technical point of view. On the basis of personal experience, the author cannot confirm this opinion. When practised cautiously by a qualified surgeon, its performance is relatively easy and without great danger.

According to the extent of the affection of the femur, a partial or a total "turn-up-plasty" is necessary. If a tumor is situated in the lower portion of the thigh, it is sufficient to resect the distal two thirds of the femur. In this event, we substitute for the resected portion the superior two thirds of the leg,—that is, we do a partial "turn-up-plasty" (Fig. 1). If the tumor is localized in the superior portion of the thigh, we are compelled to do a complete resection of the femur. In these cases we do a total "turn-up-plasty" and replace the femur by the whole length of the leg (Fig. 2).

PARTIAL RESECTION OF THE FEMUR FOLLOWED BY TRANSPLANTATION OF THE TIBIA AND FIBULA

The operation is performed with general or spinal anaesthesia, the patient lying in the supine position. After elevation of the extremity for a few minutes, the limb is constricted by an Esmarch bandage from the toes to the hip joint. Then a Steinmann pin is

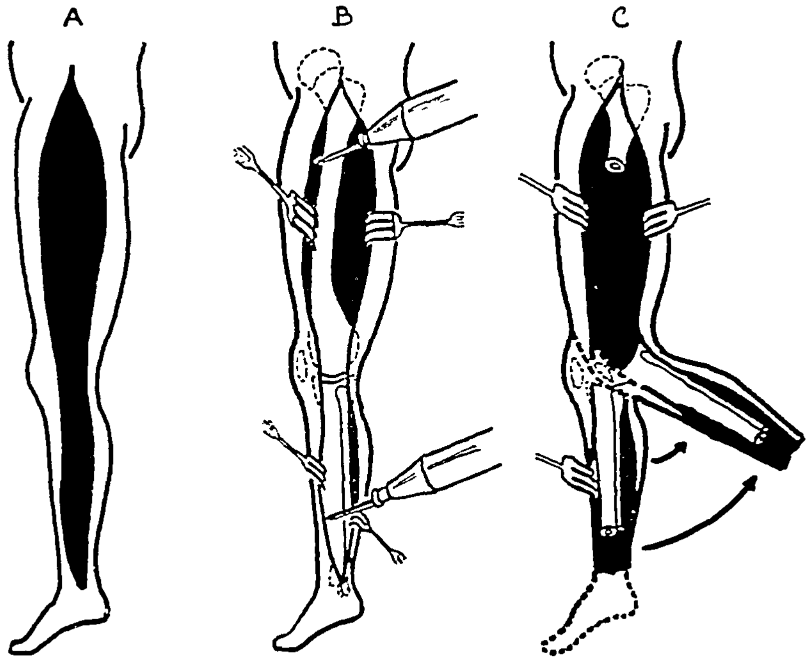

FIG. 1
Technique of partial turn-up-plasty.

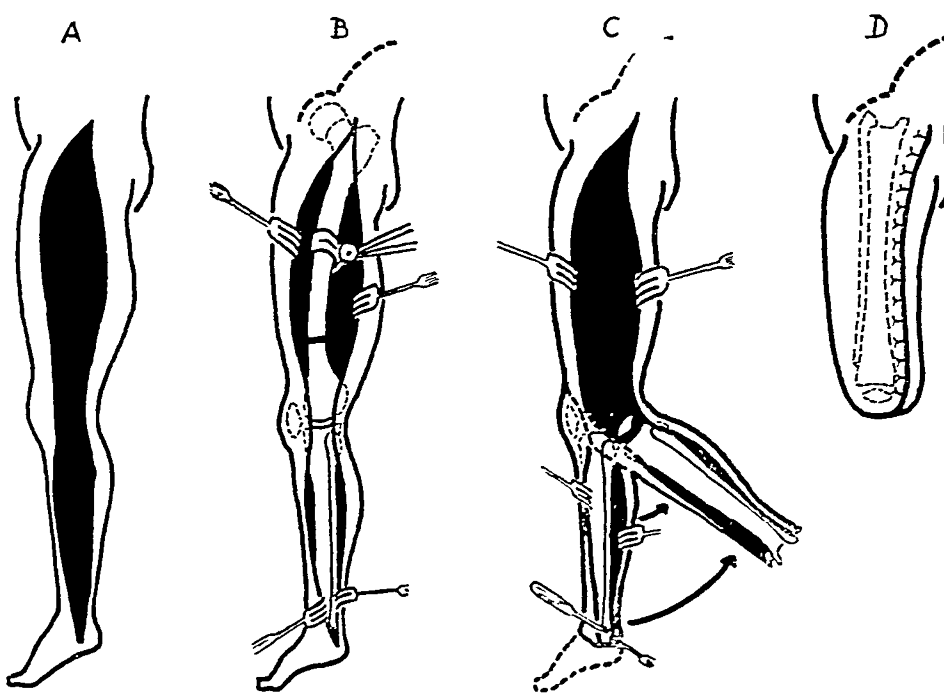

FIG. 2
Technique of total turn-up-plasty.

placed in the trochanter, and an elastic tourniquet is applied above it for the control of hemorrhage. After draping has been done, a skin flap, three inches wide, is excised on the lateral surface of the extremity, from immediately distal to the tourniquet as far as the lateral malleolus. The borders of the wound are dissected anteriorly and posteriorly.

Fig. 3-A
Case 1. Postoperative roentgenograms of partial turn-up-plasty.

In the case of a tumor of the distal portion of the femur, the vastus muscles and the rectus femoris are left attached to the bone.

The femur is reached between the vastus lateralis and the biceps, three inches distal to the trochanter. With a Gigli saw or other bone saw, the femur is transected at this point. Following the plane between the vastus lateralis and the biceps, the posterior surface of the distal portion of the femur is freed. After the rectus and vastus muscles have been divided in the plane of bone section, the femur with the covering muscles (rectus and vasti) is loosened from the adductors and flexors, care being taken not to hurt the femoral vessels in the adductor canal.

After section of the ligaments and capsule of the knee joint, the inferior portion of the femur is resected, the patella being left in place. After tampons have been placed in the cavity of the resected femur, the leg is amputated, three inches above the ankle joint, by the simple guillotine method.

One inch of the proximal end of the fibula is next removed. Then the leg is turned up in the frontal plane through 180 degrees, so that the distal end of the tibia is placed against

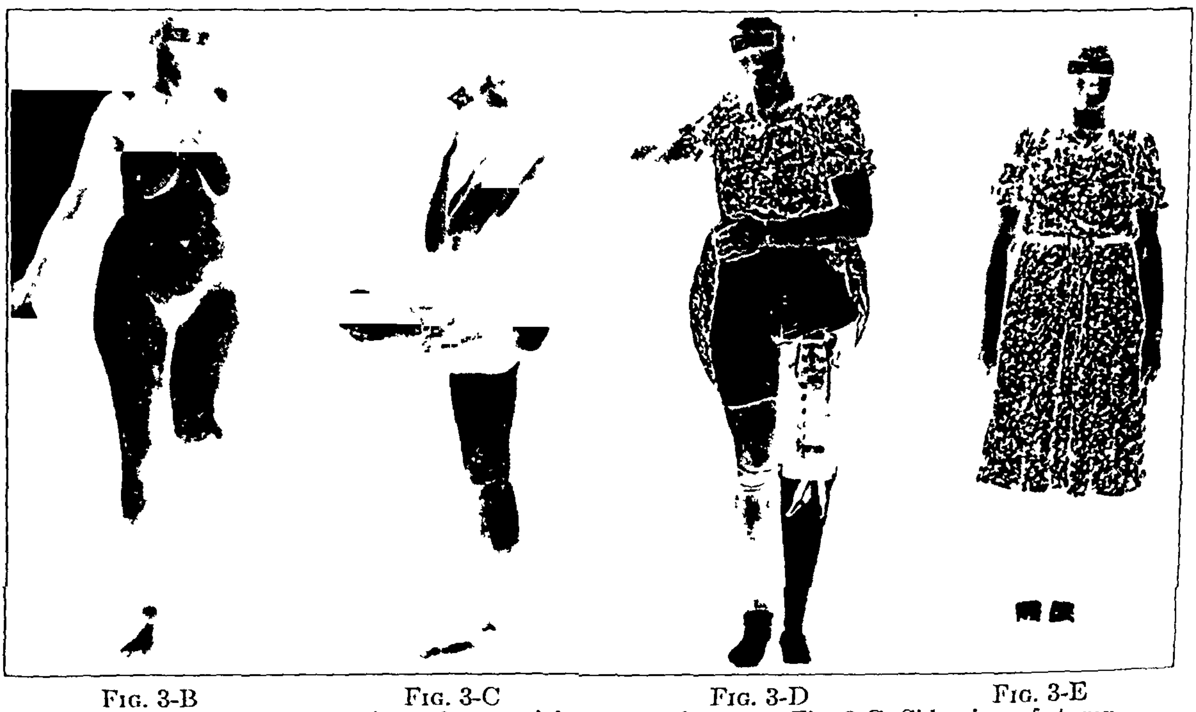

Fig. 3-B Fig. 3-C Fig. 3-D Fig. 3-E
Fig. 3-B: Front view of patient after partial turn-up-plasty. Fig. 3-C: Side view of stump.
Fig. 3-D: Patient showing prosthesis. Fig. 3-E: Shows patient clothed, wearing prosthesis.

the distal end of the remaining portion of the femur. The femur and tibia are fastened by one of the usual methods of osteosynthesis (an intramedullary pin or peg, or plate and screw fixation). The intact muscles of the thigh are sutured to the leg muscles. Finally the skin flaps are trimmed and the wound, in the form of an inverted Y, is closed in the usual manner. The patella is fixed to the tibia by a small Steinmann pin.

The last step in the operation is the application of a hip plaster, the stump being placed in the neutral position.

TOTAL RESECTION OF THE FEMUR FOLLOWED BY TRANSPLANTATION OF THE TIBIA AND FIBULA

Because of the impossibility of controlling hemorrhage by the application of a tourniquet, this operation is best performed with the patient under spinal anaesthesia. The patient lies in the supine position, with a sandbag under the gluteal region.

A skin flap, three inches wide, is excised from the lateral surface of the lower extremity, from the anterior superior iliac spine to the lateral malleolus. After dissection of the borders of the wound anteriorly and posteriorly, the femur is reached, three inches above the knee joint, in the plane between the vastus lateralis and the biceps. At this point the diaphysis is divided with a Gigli saw or other bone saw. While the muscles suspected of involvement (rectus and vasti) are left in connection with the bone, the proximal portion of the femur is separated from the adductors and flexors. As the operator works upward, the gluteal muscles are cut from the trochanter. Next the capsule of the hip joint is opened and sectioned by a circular movement, a cuff of capsule being left on the border of the acetabulum. After this, disarticulation of the femoral head and freeing of the proximal portion of the femur are easily performed. The distal portion of the femur is now loosened from the surrounding muscles and disarticulated at the knee joint.

After several tampons have been placed in the great wound cavity of the thigh, the foot is disarticulated at the ankle joint in a simple manner, the incision of the Syme amputation being used. Next the leg is turned up in the frontal plane through 180 degrees. The lateral malleolus is placed in the hip socket, and the hip capsule is sutured to the capsule of the ankle joint.

The gluteal muscles are fastened with linen sutures to the medial malleolus, which now acts as trochanter. After fixation of the intact muscles of the thigh to the leg muscles and trimming of the skin flaps, the wound is closed with interrupted sutures. Just as in the partial resection of the femur, the patella is nailed to the tibia by means of a small Steinmann pin.

At the close of the operation, a hip plaster is applied with the leg in slight abduction. After two weeks the plaster is removed, and the patient begins to exercise his new hip joint.

By the use of the technique described, a long stump is obtained, reaching to the level of the knee joint. The patella rests on the distal end of the stump and gives a good support for the prosthesis. The vessels and nerves remain undisturbed; they make a loop in the popliteal fossa and continue their course in an upward direction. The sensibility is uninterrupted, so that scratching or pinching of the skin on the lateral surface of the stump is localized by the patient as on the medial side of the former leg. Because the nerves are intact, the amputee never complains of pain due to neuroma.

CASE REPORTS

CASE 1. A woman, aged thirty-three years, was first seen in January 1942. Her left knee had been operated upon twice in another hospital.

On examination we found a hard, painful tumor of the medial condyle of the left femur. The roentgenograms showed a cystic appearance of the inferior end of the femur, with honeycomb structure. A probable diagnosis of giant-cell tumor of the femur was made.

At operation, on February 3, the condyles of the femur were found to be filled with a mucous, cartilaginous mass which was scraped out with a curette. On the basis of microscopic examination, a diagnosis of myxochondroma was made.

During September 1942, the patient complained of pain higher in the thigh. The roentgenograms showed an expansion of the tumor in the direction of the diaphysis. Another operation was performed on October 3. The tumor had penetrated in the diaphysis to a point four inches from the knee joint. Microscopic examination resulted in a diagnosis of myxochondrosarcoma.

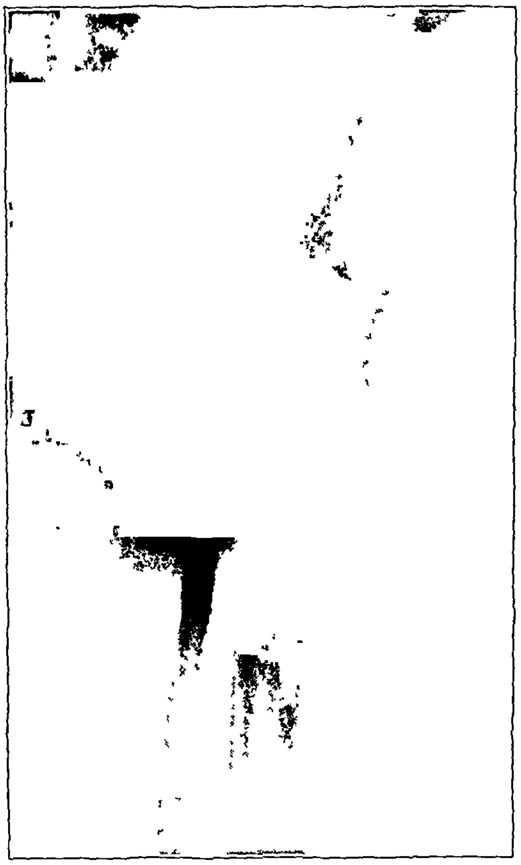

Fig. 4-A

Fig. 4-B Fig. 4-C

Fig. 4-A: Case 2. Postoperative roentgenogram after total turn-up-plasty.
Fig. 4-B: Front view of patient after total turn-up-plasty.
Fig. 4-C: Side view of stump.

Because of the various local reappearances and the result of the second microscopic examination, a more radical form of treatment seemed to be indicated. The high-femur amputation was rejected by the patient, and partial "turn-up-plasty" was carried out on October 10, 1942. The patient made an uneventful recovery (Figs. 3-B and 3-C). A few weeks later, she walked with a temporary prosthesis (Figs. 3-D and 3-E); after a short time, she walked without a cane and resumed her employment as a nurse. When she was last seen, in June 1947, she was in perfect health and walked easily with her prosthesis.

Case 2. A man, aged twenty-one years, was admitted to the Anna Clinic in January 1947, because of pain in the left thigh, which had been noticed first in September 1945. He had been treated by roentgenotherapy in another clinic, without benefit. Finally, a disarticulation of the hip had been suggested.

On admission, we found a tumor of the upper portion of the left thigh, localized particularly in the region of the greater trochanter. The tumor was fusiform and painful, and caused considerable limitation of flexion of the knee. The roentgenograms disclosed destruction of the cortex of the femur for a distance of six inches.

A biopsy was performed on February 28, 1947. On the basis of microscopic examination, the following diagnosis was made: sarcoma, formed chiefly of round and fusiform cells, typical of a perithelioma; no evidence of Ewing's tumor.

The total "turn-up-plasty" was performed on April 3, 1947, and succeeded according to expectation. The postoperative course was uneventful. On May 10, the patient received his temporary prosthesis. A few days later he went home, walking with crutches (Figs. 4-A, 4-B, and 4-C). The movements of his new hip joint were increasing from day to day.

1. Sauerbruch, F.: Die Exstirpation des Femur mit Umkipp-Plastik des Unterschenkels. Deutsche Ztschr. f. Chir., *169*: 1–12, 1922.

TRANSVERSE ROTATION OF THE SEGMENTS OF THE LOWER EXTREMITY IN LOCOMOTION *

BY A. S. LEVENS, M.S., C.E., BERKELEY, VERNE T. INMAN, M.D., SAN FRANCISCO, AND J. A. BLOSSER, M.D., BERKELEY, CALIFORNIA

From the University of California, College of Engineering, and Division of Orthopaedic Surgery, Medical School

A complete analysis of human locomotion is difficult. The fact that persons walk and run with apparent ease, and without conscious effort, does not imply that the mechanisms employed are simple or readily understood. A comprehensive study of locomotion includes not only analysis of the movements of the various segments of the body, but also the correlation of these movements with force studies and muscle action. Consideration of a problem of such complexity suggests that delimitations are necessary, and the present study endeavors to present but one component in the displacement pattern of the lower extremity.

Many investigators have reported their findings with regard to the movements of the various segments of the body, as projected upon the parasagittal plane. Few have described the motions projected onto the frontal plane. It is doubtful that any previous observers have attempted to measure the transverse rotatory motions of the various segments of the lower extremity, as projected upon a horizontal plane. It is conceivable that little attention has been given to transverse rotatory motions, possibly because motion in the parasagittal plane has usually been regarded as a more significant action in human propulsion.

Present indications are that transverse rotations of the various segments of the lower extremity are an important factor in the ease and rhythm of walking of normal individuals. In order to improve function, reduce fatigue, and prevent more or less continual abrasion at critical points on the stump of the amputee, provision in the prosthesis for allowing transverse rotations of the same order of magnitude as those in normal legs may be a major contribution toward the improvement of artificial legs.

Transverse rotations, as discussed herein, refer to angular displacements of the various bone segments of the leg about their longitudinal axes. Results are presented of a study of these movements in twenty-six normal individuals, twelve of whom provided completely satisfactory data.

The primary objectives in this study were:

1. To determine the magnitude of transverse rotations of the segments of the lower extremity, and their relative transverse rotations with respect to each other.
2. To formulate ideas for design with regard to artificial limbs.

TECHNIQUES

Placement of Pins

Stainless-steel threaded pins, 2.5 millimeters in diameter, were drilled firmly into the cortices of the various bony prominences adjacent to the hip and knee joints, sterile precautions and local anaesthesia being used. Targets, each consisting of a light wooden rod with spheres attached at two points, were fastened to the pins. Figure 1 shows pins No. *1*, No. *2*, and No. *3*, placed in the iliac crest of the pelvis, in the adductor tubercle of the femur, and in the upper portion of the tibia (tibial tubercle), respectively. The insertion

* In September 1945, a research project on prosthetic devices was undertaken at the University of California, supervised by Professor H. D. Eberhart of the Civil Engineering Division. The work was initiated by the National Research Council, at the request of the Surgeon General of the Army. The national program is directed by the Committee on Artificial Limbs of the National Research Council.

of pin No. 2 into the medial side of the femur was dictated by the fact that placement from the lateral aspect so restricted movement of the iliotibial tract that motion at the knee was suppressed.

Collection of Data

A photographic record of the movement of the targets was obtained by three synchronized 35-millimeter motion-picture cameras, operating at forty-eight frames per second, with a shutter speed of 1/96 second, oriented at distances of twenty-five feet from the subject. The cameras were so located as to refer the targets to three mutually perpendicular co-ordinate reference planes (Fig. 2). In this manner top, front, and side views of

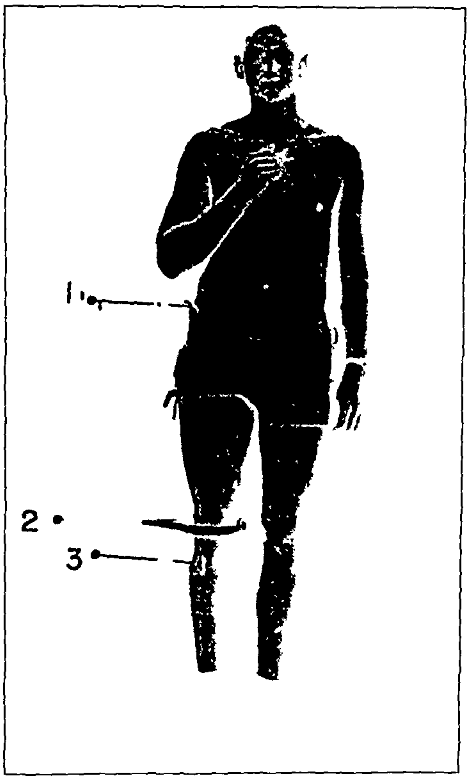

Fig. 1

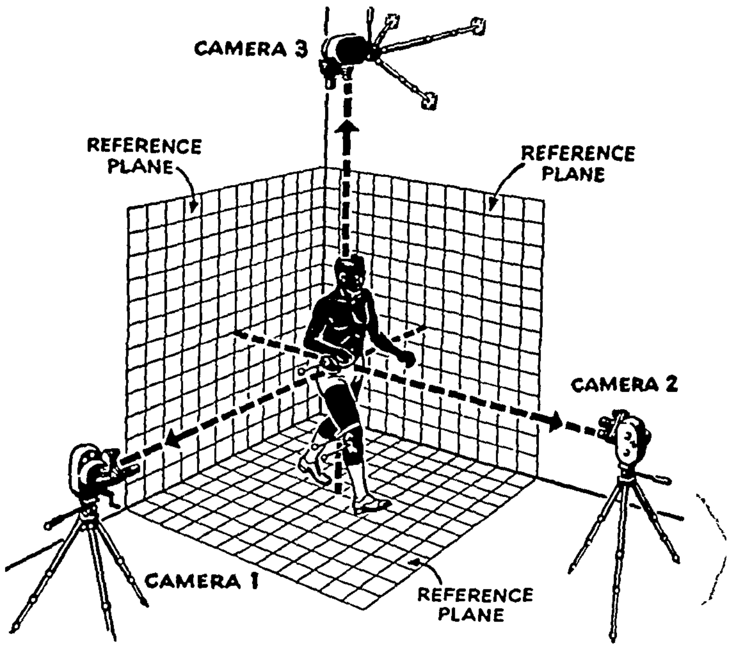

Fig. 2

Fig. 1: Subject with pins and targets attached.
Fig. 2: Arrangement for recording pin-study data. (Reproduced, by permission, from *Popular Science Monthly*, page 82, July 1947.)

the subject were obtained simultaneously. A clock mechanism made it possible to identify related frames, which were studied from enlarged projected images.

Reduction of Data

The first method employed in the reduction of data made use of computed space co-ordinates of the targets. This was felt necessary to correct for possible errors due to perspective and parallax. Later it was found that in certain cases the values of the angles between pins, obtained from orthogonal projections, compared quite favorably with values obtained from measurements taken directly from the photographs, showing the projections upon the horizontal plane only.

Further study showed that if the pins were set horizontally or within 10 degrees of horizontal, the angle between the pins, read directly from the photographs showing horizontal projections, yielded results that were within 2 degrees of the true values for the middle 60 per cent. of the stance phase; the maximum variation between values obtained by the two methods was 5 to 6 degrees at the instant of toe-off. Phase relationships were not affected by the results obtained from the two methods. The differences between computed values and those obtained directly from the motion-picture frames were not significant, since the variations were less than the variations among the individuals tested.

TABLE I

DATA ON ALL SUBJECTS* FROM PIN STUDIES

Subject	Age (Years)	Weight (Pounds)	Height (Feet)	Height (Inches)	Remarks
1	24	185	6	4	Mechanical difficulties; no data
2	27	150	6	2	One pin only; no data
3	40	180	5	9	Pins not set properly; one pin bent
4	21	168	5	11½	Excessive pin vibration
5	19	160	6	0	Excessive pin vibration
6	26	150	5	10	Excessive pin vibration
7	20	160	5	11½	Excessive pin vibration
8	25	162	6	1	Satisfactory data
9	21	165	5	11	Gait affected by pins; no data
10	21	175	6	1½	Pin loosened; no runs made
11	27	152	5	11	Satisfactory data
12	24	165	5	10	Satisfactory data
13	23	175	6	1½	Satisfactory data
14	23	170	5	9	Satisfactory data
15					Below-the-knee amputee; no pins
16	27	152	5	3	Satisfactory data
17	21	180	6	2	Bad limp; pain; no data
18					Bilateral amputee; no pins
19					Above-the-knee amputee; no pins
20	23	145	5	9½	Limping; one leg short
21	28	140	5	6	Removed pin No. 1; pain
22	28	175	5	8	Tibial pin No. 3 broken
23	23	200	6	7	Satisfactory data
24	26	145	5	8½	Satisfactory data
25	23	180	6	0	Satisfactory data
26	25	182	6	1	Pin No. 2 worked loose
27	19	160	5	11	Satisfactory data
28	27	135	5	10	No complete usable cycle
29	21	160	5	7	Data not reduced

*Twenty-six normal subjects and three amputees.

Test Results

Twenty-six normal subjects, varying in age from nineteen to forty, were studied. No data were obtained from the first seven subjects because of excessive pin vibration, bending of pins, single pin settings, and mechanical difficulties. Of the remaining nineteen subjects, the data from seven were not used for the reasons shown in Table I. Twelve of the subjects were considered satisfactory for study and analysis. The pin data obtained from the photographs were plotted on a rectangular co-ordinate system, in which the horizontal axis represented time in seconds and the vertical axis represented transverse rotation in degrees.

Complete analysis has been made only of the data dealing with the top view, in straight and level walking. Data dealing with front and lateral views, in straight and level walking, will be presented in subsequent publications.

Discussion of Curves

Curves obtained from motion-picture records of twelve normal subjects performing straight, level walking, as viewed from above, showed the same general pattern of action, although the magnitudes of inward and outward transverse rotation varied in individual cases.

Detailed study and analysis of individual and composite curves of all subjects (Fig. 3) had to be based on the action of both legs, since the significant changes occurred with rela-

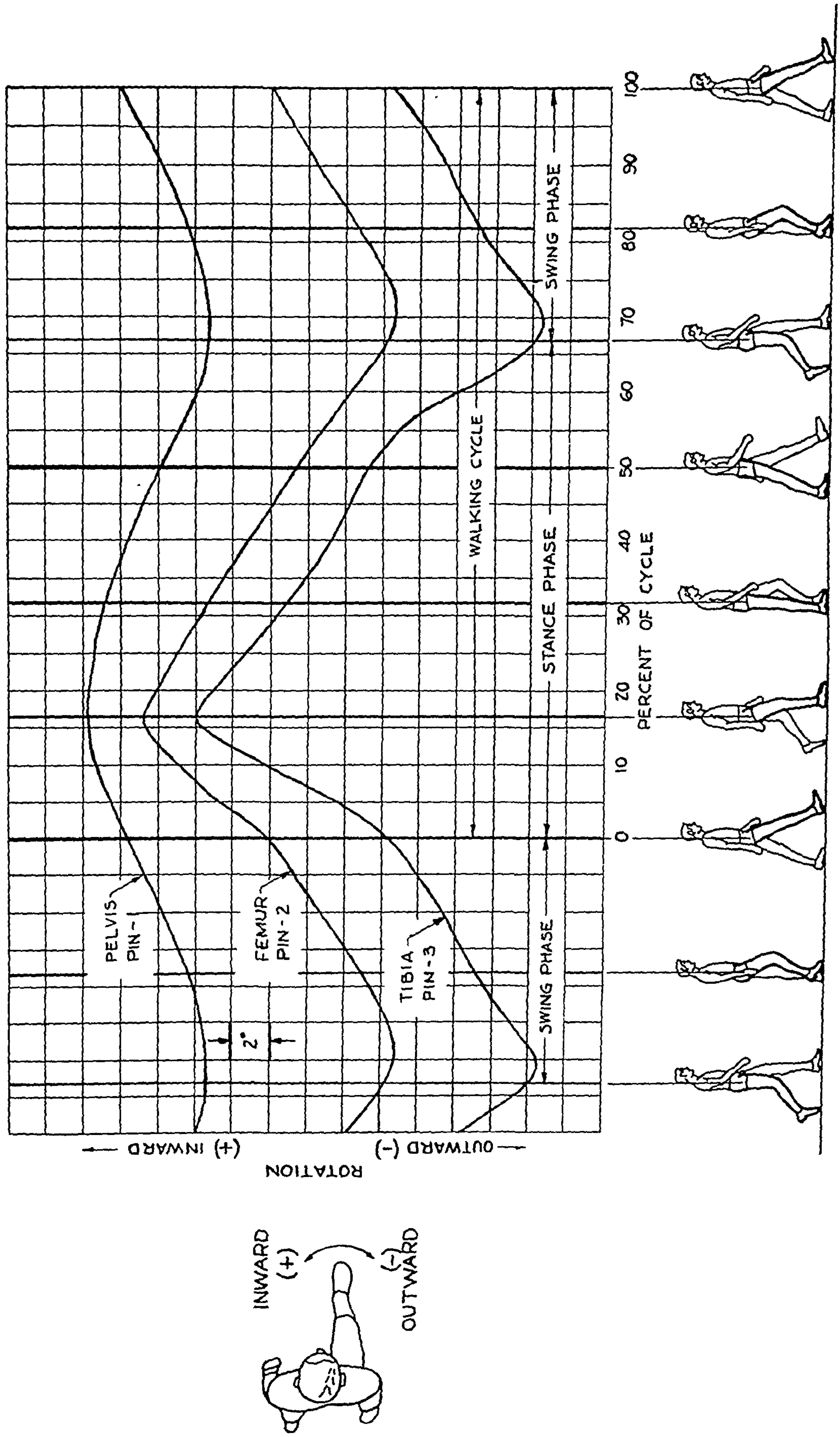

Fig. 3

Composite curves for all subjects, showing transverse rotations of pelvis, femur, and tibia.

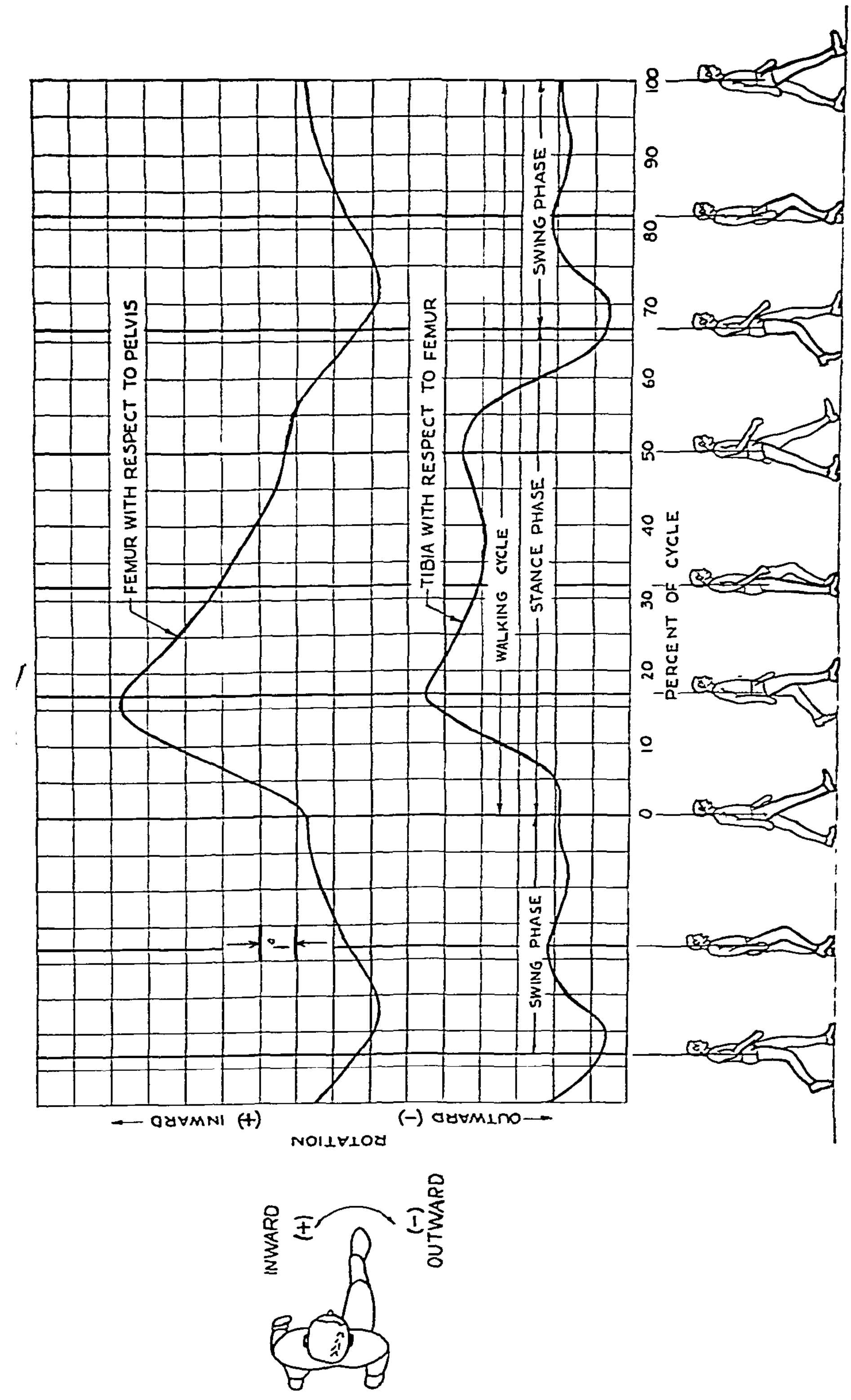

Fig. 1

Relative transverse rotation at hip joint and knee joint for all subjects. (Data from Fig. 3.)

TABLE II

Range of Transverse Rotation

Subject	Pelvis—Pin No. 1 (*Degrees*)	Femur—Pin No. 2 (*Degrees*)	Tibia—Pin No. 3 (*Degrees*)
8	8.0	17.6	25.6
11	9.8	9.6	16.4
12	4.0	10.2	23.0
13	4.7	15.0	15.0
14	10.0	17.2	19.6
16	7.2	9.8	13.4
21	Not in	24.8	22.8
23	8.4	18.0	15.0
24	3.0	14.0	17.0
25	7.4	8.6	17.4
26	9.4	Loose	21.4
27	13.3	23.3	24.1
Maximum	13.3	24.8	25.6
Minimum	3.0	8.6	13.4
Average	7.7	15.3	19.2

tion to positions of each leg. The following leg positions proved to be of salient importance:

1. Toe (of extremity with pins) leaving the floor;
2. Foot of swinging leg abreast of other foot;
3. Heel (of extremity with pins) striking the floor;
4. Foot flat, other foot at toe-off;
5. Foot flat and abreast of other foot;
6. Heel (of extremity with pins) rising and heel of other foot striking.

The time during which the foot is in space is the swing phase, and the time during which any part of the foot is in contact with the floor is the stance phase. These two phases comprise a walking cycle of one extremity.

From the time the foot of the pin-loaded extremity leaves the floor (toe-off), until the moment it comes abreast of the other foot, the pelvis, femur, and tibia have started the cycle of inward rotation. At the time the feet are abreast of each other, there is a definite increase in the rate of rotation of the femur and the tibia. As the swinging leg continues to move forward, there is considerable increase in inward rotation until the heel strikes the floor, and then a rapid increase until the other foot leaves the floor. At the peaks of the curves, the pin-loaded extremity receives the full weight of the body. This period then, from the time the foot leaves the floor until the full weight of the body is on the foot, is characterized by inward rotation of all segments (pelvis, femur, and tibia), the distal parts rotating more than the proximal ones. Beyond this point, outward rotation of all segments takes place until the foot of the pin-loaded extremity again leaves the floor; and is related to the period of increased forward and upward acceleration of the body. Here again, the distal segments rotate more than the proximal ones. In addition, the more significant features of these curves are related to weight-bearing, in that inward rotation starts with a minimum of weight-bearing and terminates with full weight-bearing, whereas outward rotation starts with full weight-bearing and ends with minimal weight-bearing. Rotation of the tibia is momentarily suppressed just as the heel-striking position is reached, while the pelvis and femur continue inward rotation. Tibial rotation is again suppressed just before the heel-rising position, while the pelvis and femur continue outward rotation. This is shown in Figure 5-A for a single subject.

The magnitude and time of occurrence of the transverse rotation of the femur on the

TABLE III

RELATIVE TRANSVERSE ROTATION AT HIP AND KNEE JOINTS
DURING STANCE PHASE

Subject	Femur with Respect to Pelvis (*Degrees*)	Tibia with Respect to Femur (*Degrees*)
8	7 4	8 2
11	6 3	12 0
12	8 6	11 0
13	10 1	6 2
14	7 4	6 6
16	6 4	9 4
21	Pin No. 1 out	8 8
23	11 4	6 4
24	10 3	9 0
25	4 9	13 3
26	Pin No. 2 loose	Pin No. 2 loose
27	11 1	4 1
Average	8 4	8 6
Standard deviation	±2 5	±2 7

tibia are of particular interest to the clinician, for they are no doubt related to the locking mechanism of the knee. When the knee is locked, inward rotation of the femur occurs; and, in unlocking the knee, outward rotation takes place. Normally the knee locks and unlocks twice in an average walking cycle, once during the last portion of the swing phase and again near the end of the stance phase. This action was clearly shown in high-speed motion pictures of a number of normal subjects. Cadence alters the degree to which the double-locking action occurs, in that during slower rates of walking the knee tends to remain extended during the entire stance phase. The double locking is more apparent in the faster cadences.

Ranges of transverse rotation of the pelvis, femur, and tibia, as well as the maximum, minimum, and average values in each case, are shown in Table II. These values were obtained from the individual curves. While the magnitudes of transverse rotation vary in individual cases, it is of importance for the designer of mechanisms and for the clinician to have a concept of ranges of these motions and the average values. Curves for a single subject are shown in Figure 5-A. The general pattern is similar to that of the curves shown in Figure 3. As previously mentioned, however, the knee-locking effect is shown more dis-

TABLE IV

MAGNITUDES OF TRANSVERSE ROTATION OF THE PELVIS, FEMUR, AND TIBIA *

Transverse Rotation			Relative Transverse Rotation		
Member	Range (*Degrees*)	Average (*Degrees*)	Members	Range (*Degrees*)	Average (*Degrees*)
Pelvis	3 0 to 13 3	7 7	Tibia with respect to femur	4 1 to 13 3	8 7
Femur	8 6 to 24 8	15 3	Femur with respect to pelvis	4 9 to 11 4	8 4
Tibia	13 4 to 25 6	19 3			

* Complete data are shown in Tables II and III.

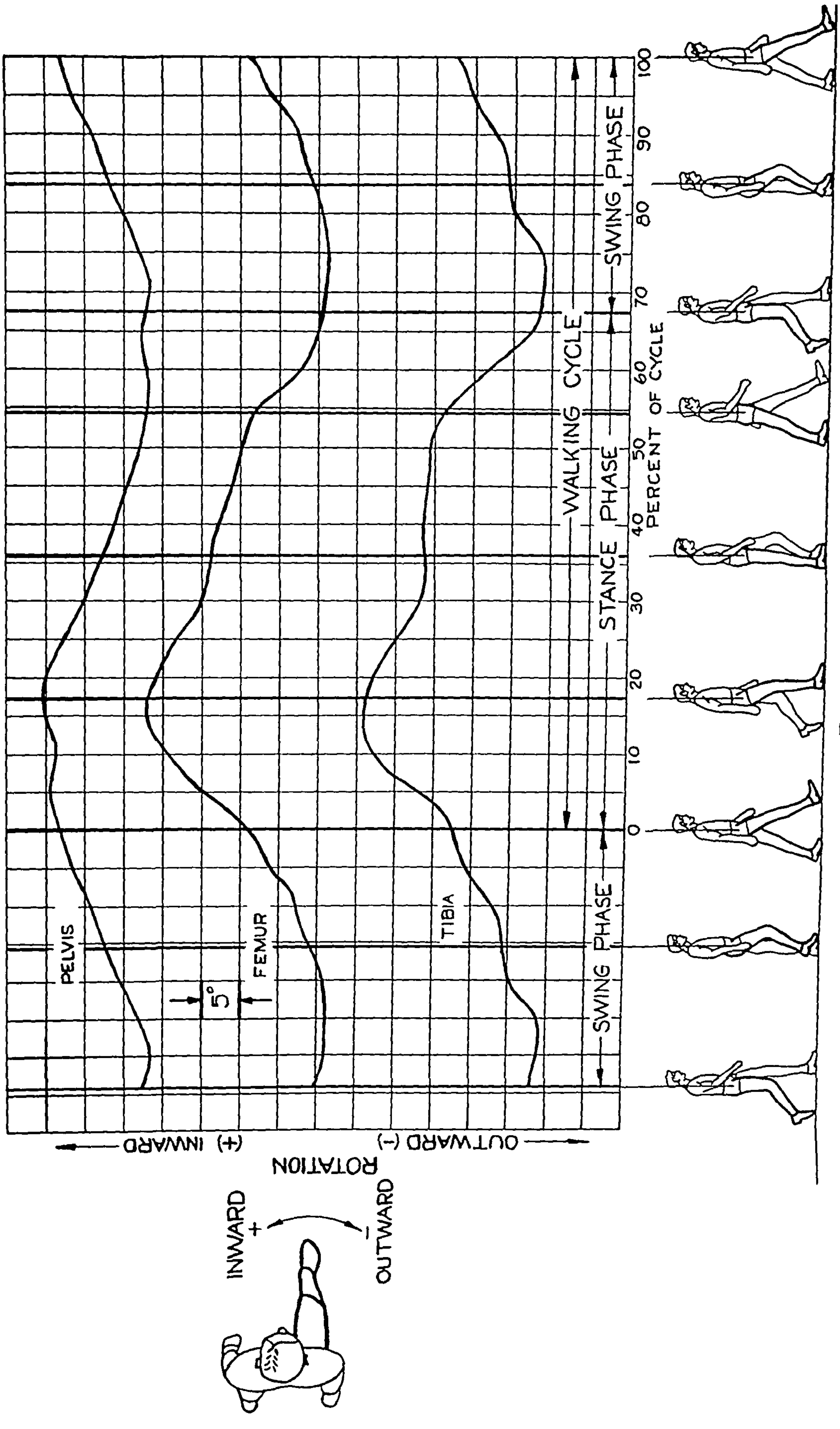

FIG. 5-A

Subject 27. Rotations of the pelvis, femur, and tibia, as viewed from above.

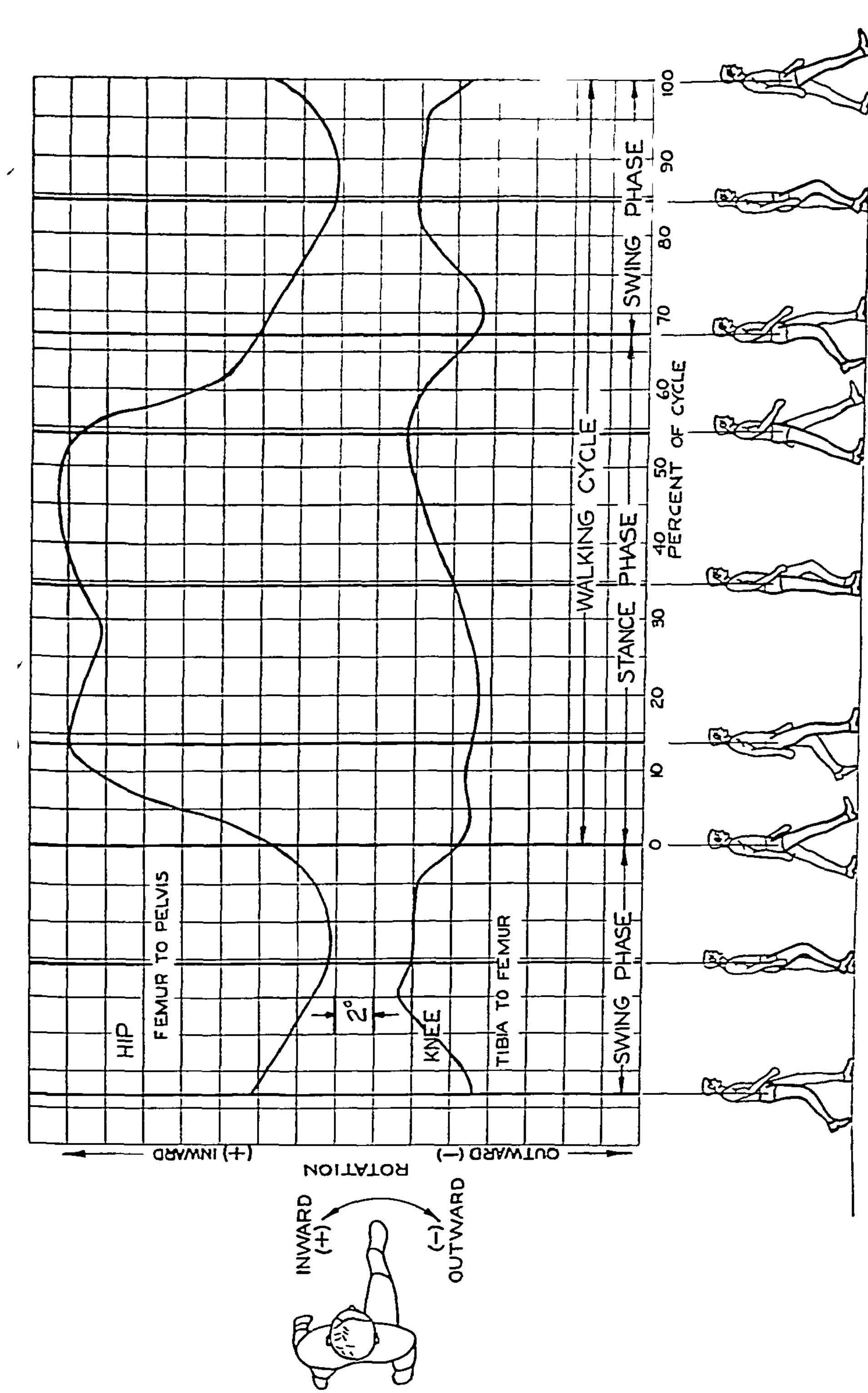

Fig. 5-B

Subject 27. Relative rotations, femur to pelvis and tibia to femur, as viewed from above

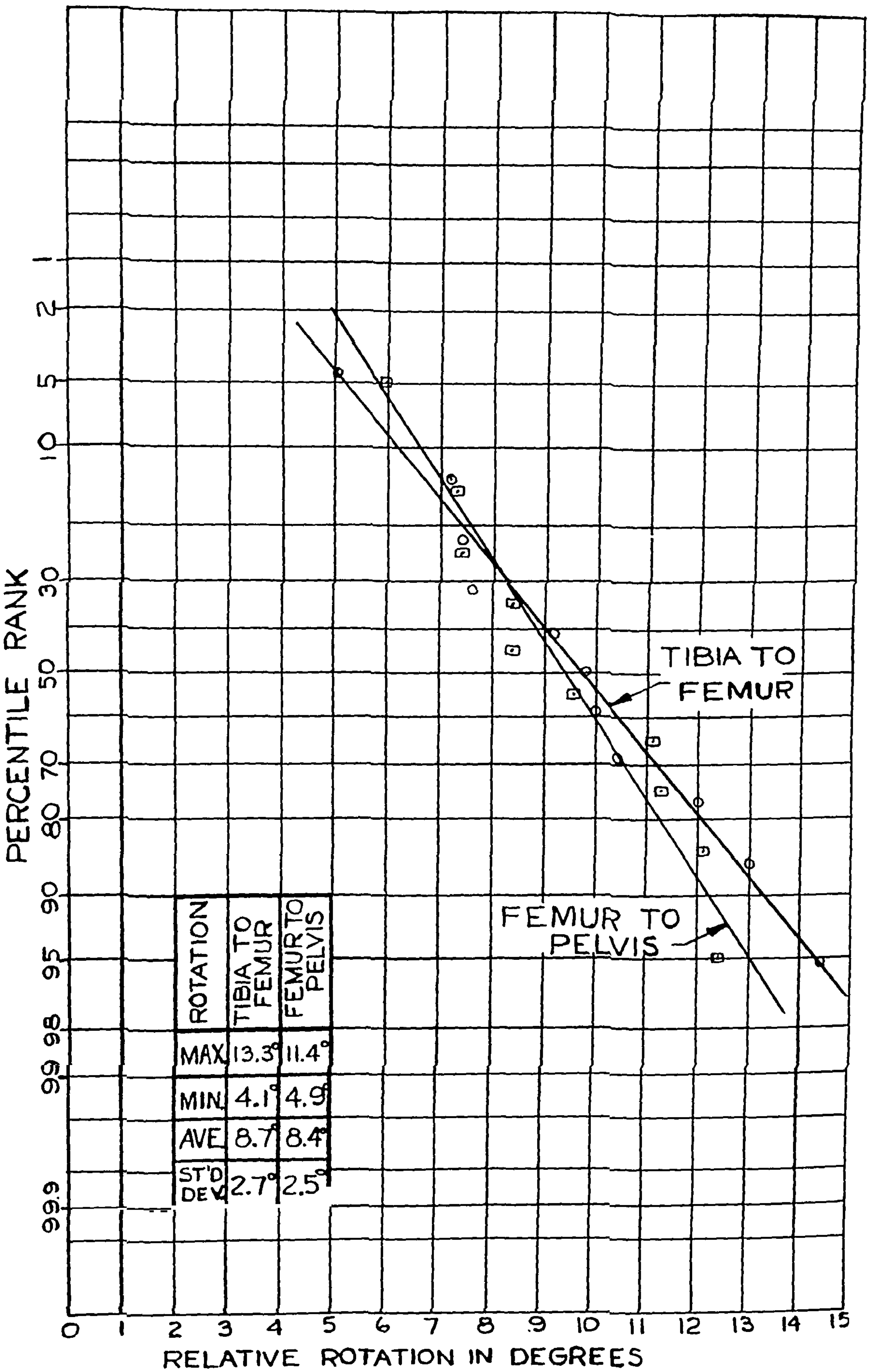

Fig. 6

Relation of rotation, in degrees, to percentile rank (during stance phase).

tinctly in the tibial curve. Note particularly the flattening of the curve near the heel-striking and the heel-rising positions of the stance phase.

While it is important to know the ranges of transverse rotation of the pelvis, femur, and tibia, it is even more significant to learn of the magnitudes of relative rotations of the femur with respect to the pelvis, and of the tibia with respect to the femur, since such values may have a bearing upon the design of artificial limbs, as well as upon the functions of the joints from a clinical point of view.

Composite curves for all subjects, showing relative transverse rotations of the tibia with respect to the femur (knee joint) and of the femur with respect to the pelvis (hip) are presented in Figure 4. In the former instance there is practically no relative rotation during the period from the feet-abreast position to the locked-knee position of the swing phase, and relative inward rotation of approximately 3.5 degrees occurs between the locked-knee position and the full weight-bearing position. Beyond this point there is a slight outward relative transverse rotation of approximately 1.5 degrees, during the interval from the full weight-bearing position to the time flexing at the knee occurs. This is followed by a very slight inward rotation of about 0.5 degree, after which there is a marked relative outward rotation of approximately 3.5 degrees as the foot reaches the toe-off position.

The relative rotation of the femur with respect to the pelvis is also of considerable interest. Throughout the period from minimal load to full weight-bearing, inward rotation of approximately 7 degrees occurs. From the full weight-bearing position to the toe-off position, outward rotation of about 6.5 degrees takes place. It should be reiterated that this discussion of results deals only with transverse rotatory motions of the various segments of the lower extremity, as projected upon a horizontal plane, and only for the cases covering straight and level walking.

In all subjects, the average relative rotation of the tibia with respect to the floor when the foot is fixed on the floor—that is, during the major portion of the stance phase—may be obtained from the tibial pin curve. The magnitude of the relative rotation is approximately 7 degrees inward, during the interval from 7 per cent. to 17 per cent. of the walking cycle; and it is approximately 8 degrees outward in the interval from 17 per cent. to 43 per cent. of the walking cycle (Fig. 3).

Ranges of relative transverse rotation of the tibia with respect to the femur and of the femur with respect to the pelvis, as well as maximum, minimum, and average values for the individual cases, are shown in Table IV. Here again, variations exist in the magnitudes of relative transverse rotations for the individual cases. A knowledge of the possible ranges and average values is of significance to both designer and clinician, since such information will be helpful both in developing mechanisms for the improvement of artificial limbs and in a better understanding of locomotion.

Figure 5-B shows the relative transverse rotations at the knee and hip joints of one subject. During the stance phase, in the interval from the heel-striking position to the feet-abreast position, very little transverse rotation of the tibia with respect to the femur takes place (about 1 to 1.5 degrees). As the knee locks, relative rotation increases inwardly about 2.5 degrees, followed by a rapid outward relative rotation of about 4 degrees as the knee flexes to the toe-off position.

During the interval from the heel-striking position to the foot-flat position of the stance phase, the relative transverse rotation of the femur with respect to the pelvis is about 10 degrees inward, followed by a shorter interval from the latter position to the feet-abreast position, during which the relative rotation is about 2 degrees outward. This action is then followed by inward relative rotation of about 2 degrees, during the interval from the feet-abreast position to the heel-rising position. From this point on, fairly rapid outward relative rotation of approximately 10 degrees occurs as the toe-off position is reached.

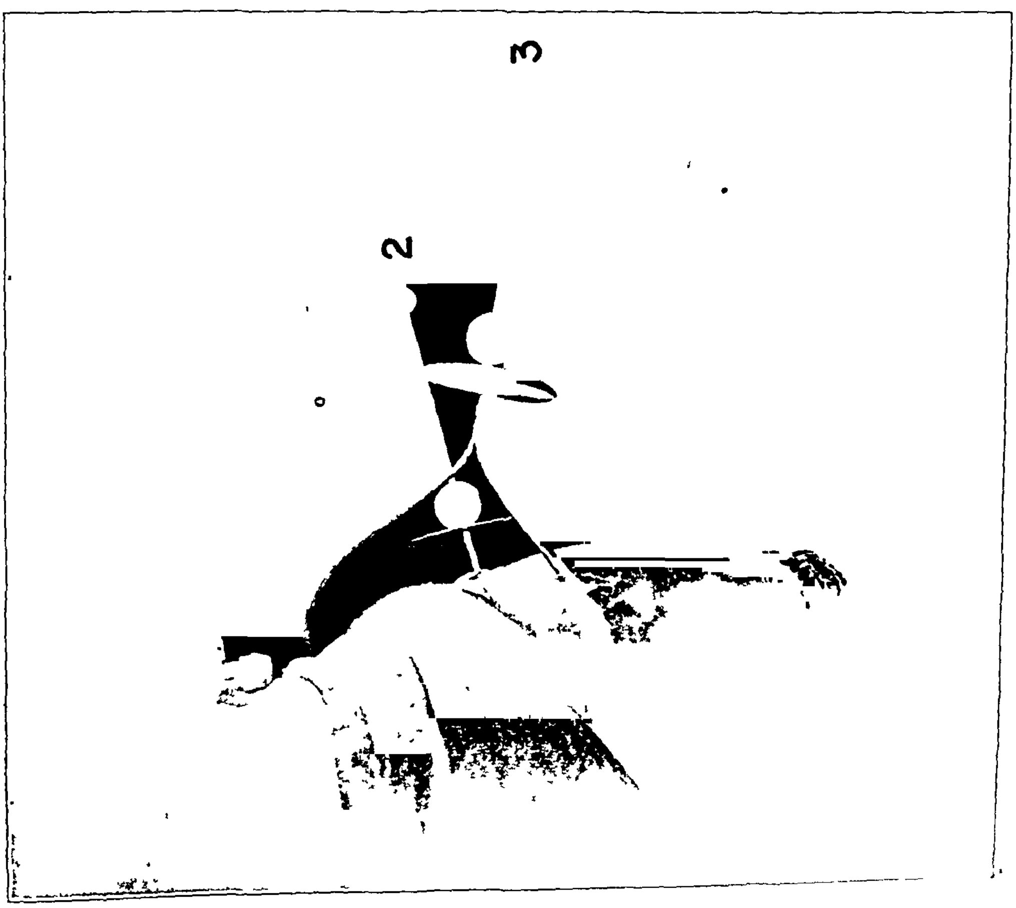

Fig. 7-A
Leg flexed.

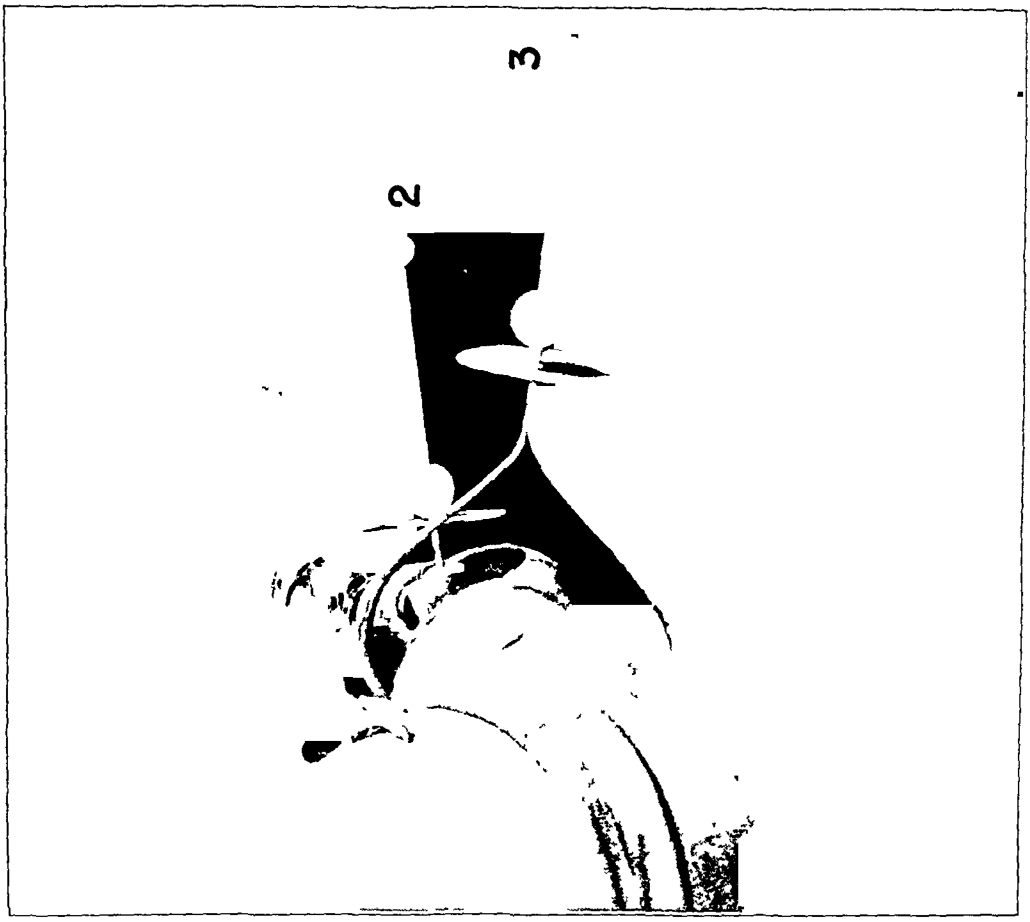

Fig. 7-B
Leg extended.

Photographs illustrating rotation of the tibia with respect to the femur at the knee joint. Camera axis along femur shows angle between pins No. 2 and No. 3.

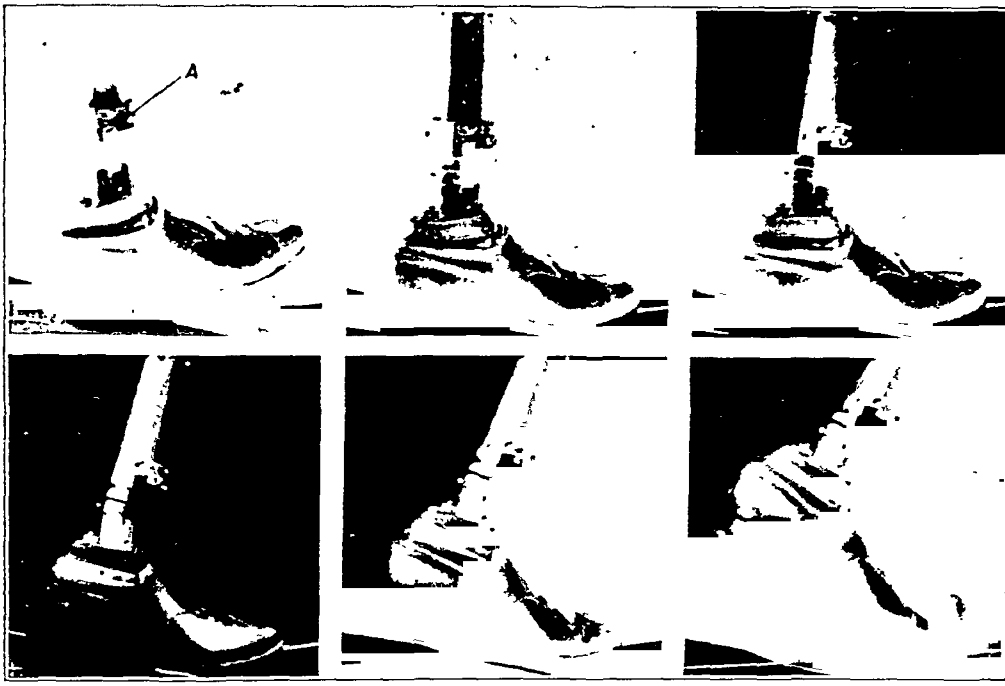

Fig. 8

Ankle-rotation mechanism during walking.

The relation to percentile rank of the relative rotations of the femur with respect to the pelvis, and of the tibia with respect to the femur, is shown in Figure 6. Ordinate values represent percentages of subjects having magnitudes of rotation less than the values shown by the corresponding abscissae. The points for both cases—femur with respect to pelvis and tibia with respect to femur—lie very nearly on straight lines, indicating a normal distribution pattern.

A striking demonstration of relative transverse rotation between the tibia and femur at the knee joint is shown in Figures 7-A and 7-B. The angular displacement caused by the change from the flexed position of the leg to the fully extended position is clearly seen in the angular change between the targets.

SUMMARY AND CONCLUSIONS

Transverse rotations of the pelvis, femur, and tibia occur in all normal individuals (Table IV). Inward and outward rotations of the segments are related to weight-bearing. Inward rotation takes place during the phase from minimal weight-bearing to full weight-bearing, and outward rotation occurs during the phase from full weight-bearing to minimal load.

The rotations of the lower extremity appear to be absorbed in the articulations of the foot and their related ligamentous structures.

Restrictions placed upon the normal transverse rotations will, to varying degrees, modify the synchrony and rhythm of walking. The awkwardness and discomfort of a patient, required to wear a leg brace which does not provide for these rotations at the hip, knee, and foot, are no doubt due, in part, to the restriction of these motions.

At the present time no prosthesis for the lower extremity has purposely incorporated mechanisms to provide for transverse rotatory motions, except on an experimental basis. Suppressing this rotation prevents the prosthesis from approaching the behavior of a normal extremity, and thus requires alterations in the normal pattern of movement of the

joints proximal to the amputation. Relative motion will take place where the resistance to torque is the least. During weight-bearing in the stance phase, this motion will tend to occur between the stump and the socket, producing a most uncomfortable force on the stump. This is particularly true of the above-the-knee suction-socket limb. In the below-the-knee amputee, in addition to the major rotations that occur between the trunk and the fixed foot position, there is further restriction of rotatory motion at the knee, produced by the side hinge bars connecting the thigh lacer and the shank. In the case of below-the-knee amputees who have adequate stump length and shape, the use of suction sockets and an ankle mechanism may make it possible not only to provide for transverse rotation, but also to do away with side hinge bars and lacers, which tend to restrict the normal action of the knee.

The incorporation of a simple mechanism which provides for transverse rotation of sufficient magnitude, together with a unit for the return of the foot to the normal position, may well constitute a major contribution to both the comfort of the amputee and the improvement of function and synchrony in walking. An experimental mechanism has been used on this project. All amputees who have employed this mechanism have attested to the very marked improvement in comfort. Figure 8 shows reproductions of frames, taken from high-speed motion pictures, of an amputee using the experimental rotatory mechanism. The frames selected for reproduction show the six salient positions of the foot during the stance phase. Attention should be called to changes in the gap (*A*) between the stops; the width of the gap shows the amount of rotation occurring between the leg and the foot. The ultimate incorporation of this device, or modifications of it, in a prosthesis may well become standard practice, and may be advantageous in leg braces.

COMPLETE DISLOCATION OF THE TALUS

BY WENDELL J. NEWCOMB, M.D., PENSACOLA, FLORIDA, AND
ERNEST A. BRAV, M.D., LOUISVILLE, KENTUCKY

This case is reported because of its rarity and because it demonstrates the need for immediate reduction, the possibility of revascularization, and the policy of preserving the talus.

A man, forty-five years old, jumped from a moving vehicle and struck the occipital portion of his skull against the ground. He suffered a mild cerebral concussion and, therefore, had no recollection of the mechanism of his associated ankle injury. He arrived at the hospital about one hour after the injury, and treatment was rendered immediately.

Physical examination showed inversion of the right foot with a marked prominence anterior to the lateral malleolus. The skin was very tense over the prominence. The roentgenograms revealed rotation of the talus 90 degrees about the horizontal and vertical axes. The position of this bone was transverse to the horizontal axis of the foot, and its posterior portion was lateral and anterior to the fibula. No fracture was noted (Figs. 1 and 2).

The treatment, carried out with the patient under spinal anaesthesia, consisted of traction by means of a Kirschner wire through the calcaneus, and countertraction on a Steinmann pin in the proximal portion of the tibia. Considerable traction was necessary before pressure in a posteromedial direction, over the lateral prominence, forced the displaced bone into the anteroposterior plane. Roentgenograms then revealed that it had rotated 90 degrees about the vertical axis, while travelling the 90 degrees of displacement in the horizontal plane.

The Kirschner wire and Steinmann pin were removed, and a toe-to-groin plaster was applied. This was immediately split anteriorly. After one week the plaster was changed; at this time a small necrotic area was

FIG. 1

FIG. 2

Fig. 1: Anteroposterior view shows the posterior portion of the talus, 90 degrees lateral to its normal position and rotated 90 degrees on the vertical axis.
Fig. 2: Lateral view shows posterior portion of talus anterior to the fibula, and confirms the rotation.

found in the skin on the lateral surface of the ankle, where the posterior portion of the talus had caused marked tautness of the skin for about one and one-half hours prior to reduction (Fig. 3). Immobilization was continued for four weeks and then active exercise was started. At six weeks after injury a mild inversion of the foot was noted. A lateral sole-and-heel wedge was applied, and partial weight-bearing was started. A gradual increase of weight-bearing was permitted during the next four weeks; during this time the daily application of heat and active exercise produced a continued increase in foot and ankle motions. In three months the patient returned to sedentary work. At the end of six months, the roentgenograms (Figs. 4 and 5) revealed mild decreased density in the superior portion of the talus, but no aseptic necrosis. Plantar flexion of the ankle was through 30 degrees, with 10 degrees of dorsiflexion. Foot movements were possible through 5 degrees of eversion and 10 degrees of inversion.

FIG. 3

Shows soft-tissue necrosis anterior to lateral malleolus, where the posterior portion of the talus caused tautness of the skin before reduction.

DISCUSSION

Collins and Collins, Sneed, Ollerenshaw, and Mitchell have all reported reduction of total dislocations of the talus, with satisfactory results. The first two authors reported compound dislocations and the last two, simple dislocations. Mitchell's case was very similar to the one presented in this report, but the dislocation in his case was of eighteen hours' duration and the postreduction necrosis over the prominence was much greater.

The majority of earlier authors, such as Stimson and Basil Norris, as cited by Sneed, advised removal of the talus in such cases; but the modern writers, including Watson-Jones, Wilson, and Key and Conwell emphasize the preservation of the talus, if possible. Watson-Jones states that

the functional result with the talus preserved is better, even when the complications necessitate arthrodesis, than the functional results following astragalectomy.

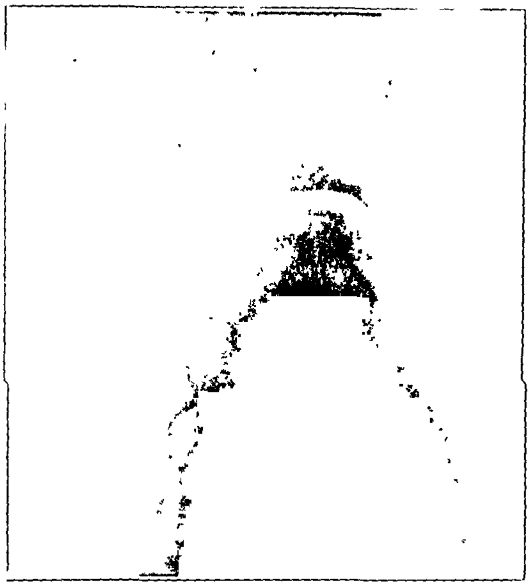

FIG. 4

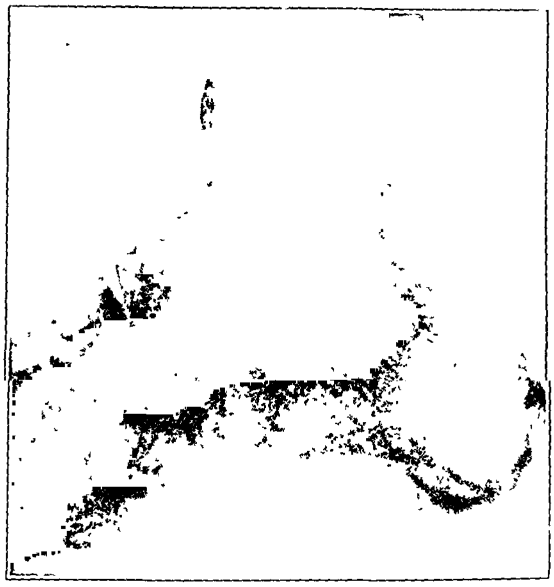

FIG. 5

Six months after reduction, no aseptic necrosis is evident.

Revascularization occurs more readily if the neck has not been fractured. The spontaneous reattachment of soft tissue supplies the necessary vascular source. McKeever and Sneed have shown that the major nutrient supply is through the dense superior talonavicular ligament, which extends as a broad band from the dorsal surface of the neck to the dorsal periphery of the navicular. Some small strands of this strong ligament probably remain attached, and through them revascularization can readily develop.

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RESULTS OF OPEN REDUCTION OF "TRUE" CONGENITAL LUXATION OF THE HIP *

BY PROFESSOR JACQUES LEVEUF†, PARIS, FRANCE

This paper deals only with "true" congenital luxation of the hip. It concerns many advances which have been made since 1946, when a book on this subject, by Leveuf and Bertrand, was published. The fundamental point in this problem remains the distinction between a true luxation and a primary subluxation.[1]

In *luxation* one always finds interposition of soft tissues between the head of the femur and the acetabulum,—that is, a narrow hourglass constriction of the capsule, confining the head; the obstruction of the acetabulum by the inferior fold of the capsule; a cartilaginous roof (or limbus), pushed down into the joint by the head; and a huge ligamentum teres which is present in half of the cases. The head is round in shape and small in size. After the interpositions have been removed, the acetabulum itself appears to be of fair size and depth.

TABLE I

PRIMARY OPEN REDUCTION IN 116 HIPS **

Age of Patients	10 months to 2 years	Between 2 and 3 years	Between 3 and 4 years	Between 4 and 5 years	Between 5 and 10 years	Total No.	Total Per cent.
Number of Cases	35	44	13	12	12	116	
Anatomical Results:							
Good..	31	36	10	11	11	99	85.3
Subluxations.	3	3	3	1	1	17	14.7
Reluxations.	1	5	0	0	0		
Epiphysitis:							
Slight.	7	3	1	0	1	27	23.3
Severe.	6	5	2	1	1		
Motion of Joint:							
I. Normal	19	19	6	4	2	95	81.9
II. Fair	11	17	7	4	6		
III. Poor (stiffness).	4	5	0	3	3	21	18.1
IV. Bad (ankylosis)	1	3	0	1	1		

** Of these dislocations, thirty-four were bilateral and forty-eight were unilateral.

In *subluxation,* interposition of soft tissues never exists. The most important lesion is the limbus, which is pushed against the iliac bone. Atrophy of the roof causes the acetabulum to assume an oval shape. The head of the femur is bulky and out of shape, so it is difficult to get good congruence of the joint after the reduction.

All of these anatomical facts are easily shown by arthrography. At the same time, one can see whether or not the closed reduction is perfect.

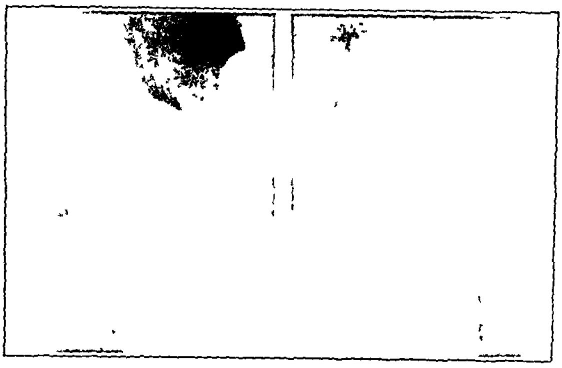
The author's present experience indicates that in true luxation, clearly established by arthrography, the interposition of soft tissues makes a correct reduction of the displacement impossible without open operation. Such an opinion is founded upon a series of facts:

1. When an open reduction is performed, the interpositions shown by arthrograms are always found.

2. When operation is performed upon a hip after closed reduction has failed, the

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1948.

† Professor Leveuf died in August 1948.



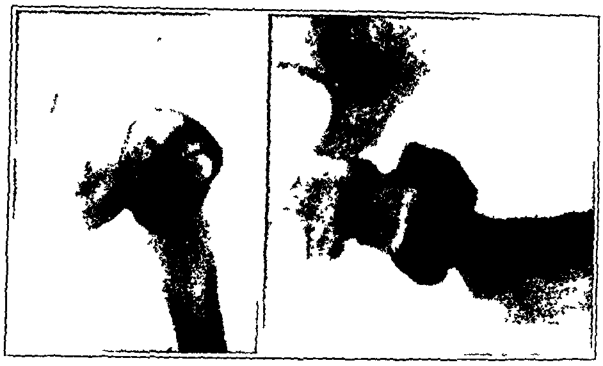


Fig. 1-A

Fig. 1-B

Fig. 1-A: Case F.; patient two years old. Showing unilateral left luxation.
Fig. 1-B: Arthrograms reveal ligamentum teres and hypertrophied limbus.

Fig. 1-C

Fig. 1-D

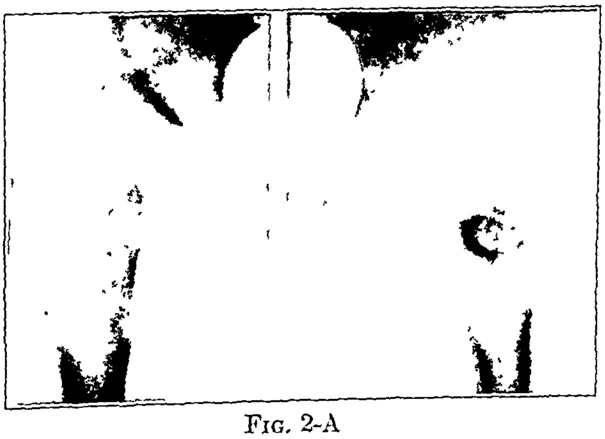
Fig. 1-C: Result one year after open reduction.
Fig. 1-D: Resected ligamentum teres and hypertrophied limbus.

interposition of soft tissue, compressed among adhesions of the joint, is always found. None of the interposed tissue has disappeared, but the head of the femur is often mushroom-shaped with erosions of its cartilaginous covering.

3. In about ten experimental cases of bilateral luxation (the same degree on both sides), the first side has been operated upon with good results; on the other side, treated by closed reduction, reluxation has always resulted.

4. In the clinic of *Pont l'Abbé*, in Brittany, we have set up statistics of congenital dislocations, based on cases treated for two years.

In thirty-six *true luxations*, the closed reduction, checked by arthrography, was tried in only four cases; the results were bad. In thirty-two patients who were operated upon, fair reductions were obtained. On the contrary, in *primary subluxations*, treated



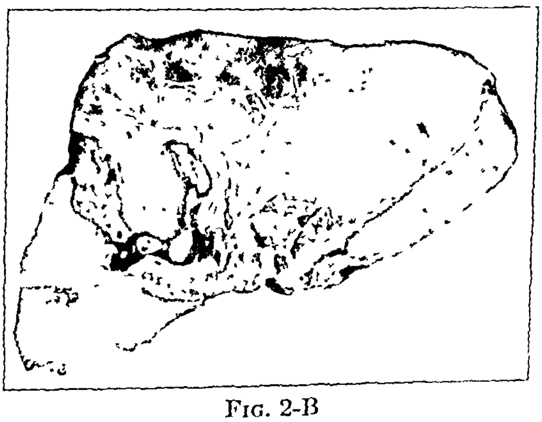


Fig. 2-A

Fig. 2-B

Fig. 2-A: Case M.; right subluxation and left luxation. Treated by closed reduction at sixteen months of age, without success.
Fig. 2-B: Specimen removed at operation, showing ulceration of the head and fibrous transformation of the cartilage.

Fig. 2-C Fig. 2-D

Fig. 2-C: Photomicrograph of fibrous portion of specimen shown in Fig. 2-B.
Fig. 2-D: Result five years after open reduction. The previous epiphysitis has persisted. Motion is fair.

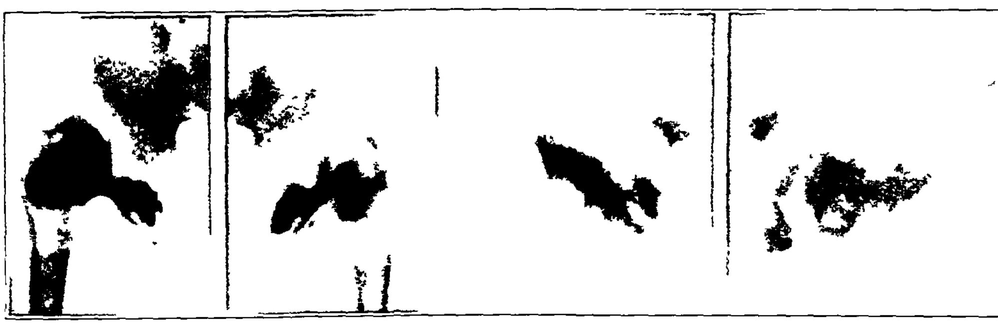


Fig 3-A Fig. 3-B

Fig. 3-A: Case A.; arthrogram showing bilateral luxation.
Fig. 3-B: Open reduction was done on the right, closed reduction on the left.

Fig. 3-C Fig. 3-D

Fig 3-C. Appearance of the hips before reduction.
Fig 3-D: The result three and one-half years after reduction. On the right (open reduction) there is epiphysitis, but the result is good. On the left, which was treated by mistake by closed reduction, the result is very bad.

before the patients were three years of age, the closed treatment gave very good results in about one-half of the cases.

For these reasons we are able to say, first, that when good results were obtained in congenital dislocation of the hip by closed reduction without arthrography, according to the former methods, the condition was a primary subluxation and never a true luxation. Second, a true luxation, duly established by arthrography, must be treated by open reduction. It is a mistake to attempt bloodless reduction in such a case, because it always fails;

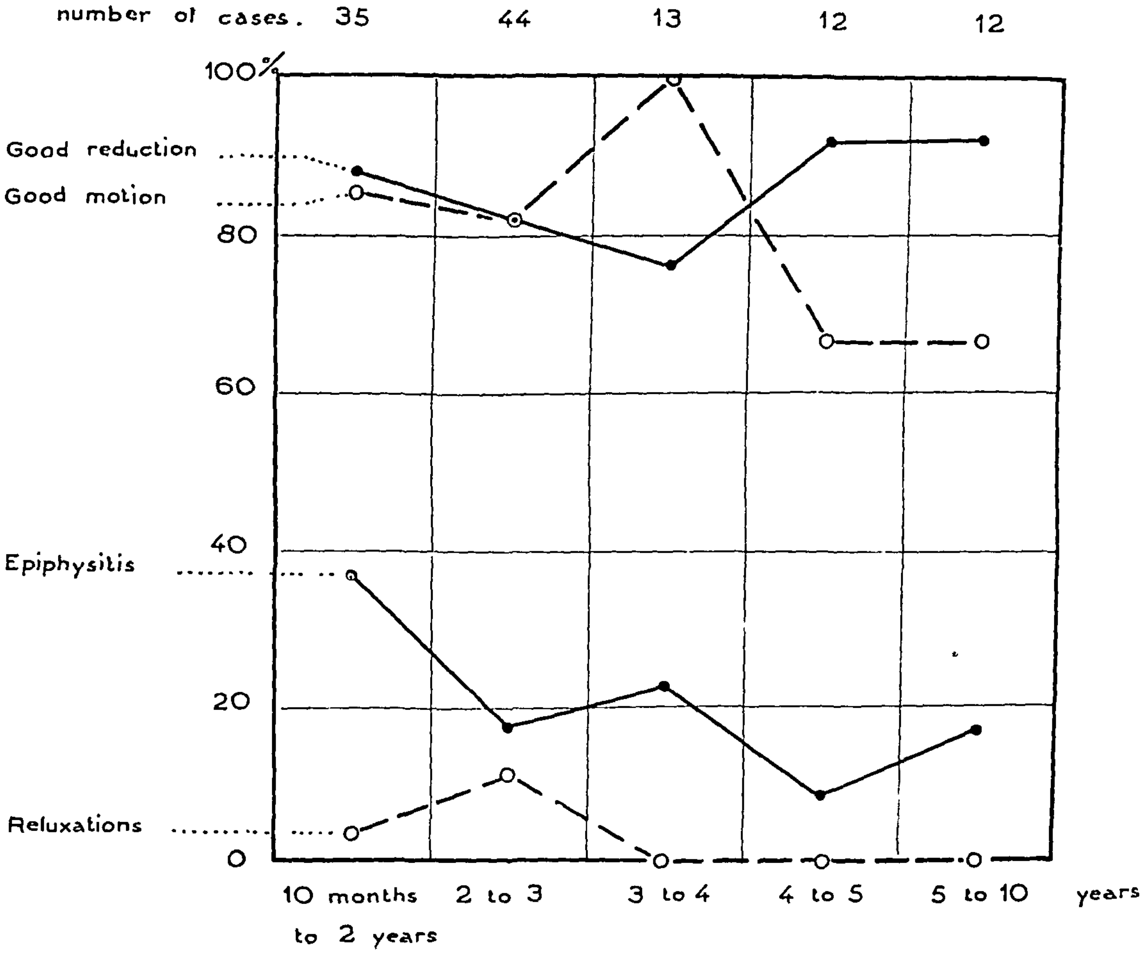


CHART I
Results in 116 hips after primary open reduction.

in addition, grave lesions of the head of the femur, produced by manipulations and by conservative treatment, result.

RESULTS FOLLOWING OPEN REDUCTION

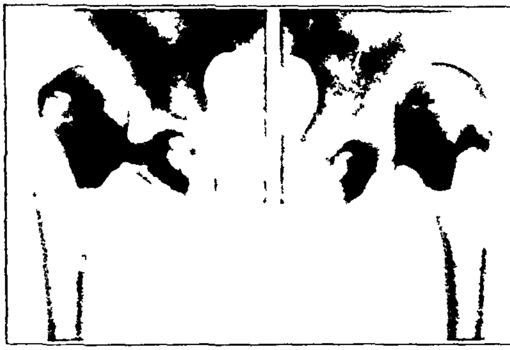
In the treatment of a true luxation, the ideal would be to deal only with young patients who had not undergone previous and quite useless manoeuvres of closed reduction, not checked by arthrography. Lacking this ideal situation, the author had to operate for other kinds of luxations.

The operation is restricted to the cutting away of the soft parts which block the acetabulum. The main point is to use a good approach to the acetabulum, of which the *Ollier transtrochanteric approach is the best. The technique of the operation was discussed* by Leveuf and Bertrand.

The operation has been used, first, in cases of high dislocation in older persons, when the head could not be replaced in the acetabulum without the femur being shortened. In these cases our routine operation has been similar to the Zahradníček technique. In addition, the author had to operate in cases of reluxation and secondary subluxation, after closed reduction had failed.

The records include all patients operated upon from January 1941 until July 1947. For simplification, the discussion concerns the number of hips operated upon. Some of the operations were unilateral and some were bilateral. The total number is 318, consisting of 119 primary open reductions, 96 open reductions with shortening of the femur, and 103 secondary open reductions for reluxation after closed treatment.

There were five deaths, three after primary open reduction, one after open reduction with shortening of the femur, and one after secondary open reduction, or a fatality rate



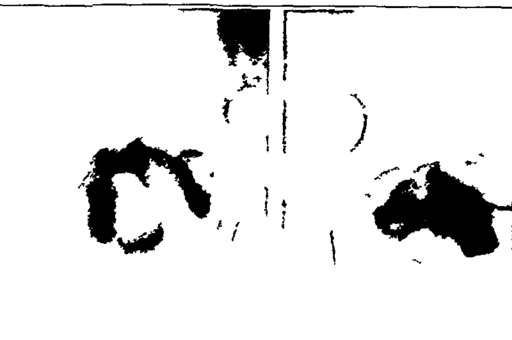
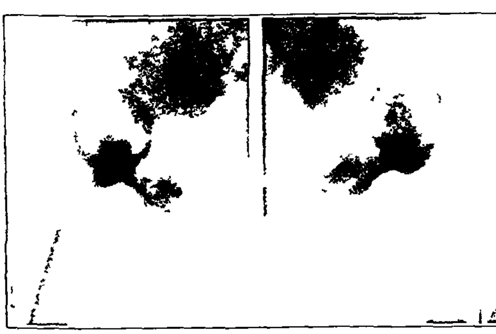


FIG. 4-A FIG. 4-B

Case C. Patient three and one-half years old. Arthrograms show bilateral luxation, before and after primary open reduction.

FIG. 4-C FIG. 4-D

Fig. 4-C. Before reduction. Fig. 4-D. Three years after operation, motion is normal.



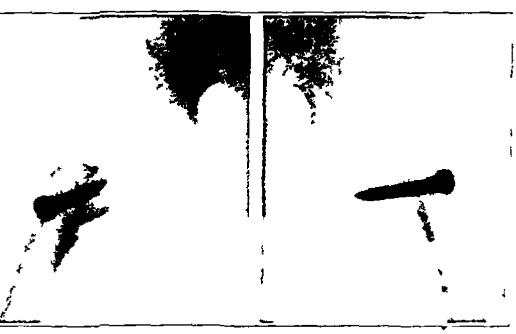


FIG. 5-A FIG. 5-B

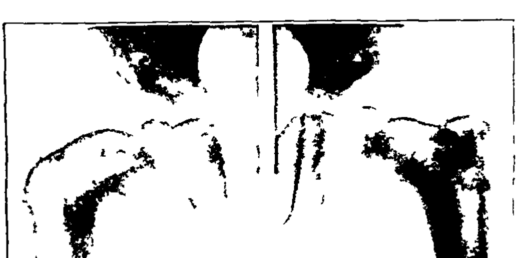


FIG. 5-C

Fig. 5-A. Case L. G., patient two years and eight months old. Shows bilateral high luxation.

Fig. 5-B. After bilateral open reduction and resection of the femur.

Fig. 5-C. One year after the operations, normal motion is possible.

of 1.57 per cent. For six years, no mortality took place. The five deaths occurred consecutively at the beginning of 1947, and are to be attributed to certain disturbances in the nursing staff.

I. *Results after Primary Open Reduction* (Chart I)

The 116 surviving cases include seventy-nine operations on patients who were three years old or under (the youngest was ten months old), and thirty-seven operations on patients between three and ten years of age (Table I).

A. *Anatomical Factors*

Of the total of 116 cases, the head of the femur was well replaced in 99 cases, or 85.3 per cent. Not only reluxation, but even any slight subluxation, has been judged a primary bad result. Most of these dislocations were reduced later by orthopaedic manipulations or by a secondary operation.

Postoperatively, the structure of the head has sometimes been found to be impaired by epiphysitis. Epiphysitis is said to be slight when the head recovers without deformity; it is said to be severe when the head remains out of shape. The proportion of epiphysitis was very large in these 116 cases. The condition was present in twenty-seven cases (23.3 per cent.); in twelve cases the epiphysitis was slight, and in fifteen a severe form was present.

In this series, the ligamentum teres was present or absent in about the same number of cases. In either circumstance, the rate of slight and of severe epiphysitis was about equal. Furthermore, the ligamentum teres was never seen to bleed after having been cut, so that excising the ligamentum teres does not appear to produce epiphysitis.

However, in thirty-five babies, whose hips were operated upon at two years of age or under, the ligamentum teres was present in twenty-three and absent in twelve. Of the twenty-three cases in which the ligamentum had been cut away, epiphysitis developed in eleven (47.8 per cent.). On the other hand, of twelve cases without the ligamentum teres, epiphysitis developed in only two (16.7 per cent.). These figures correlate with what we know about the part played by the ligamentum teres in the circulation of the head of the femur in a very young person.

B. *Motion of the Joint*

An accurate determination has been made of the state of motion in the joint after an open reduction, and the cases have been divided into four groups:

Group I: Perfect results with normal range of motion,
Group II: Good results, with the range of flexion reaching at least 90 degrees and the range of abduction reaching at least 45 degrees;
Group III: Poor results with more stiffness than in Group II;
Group IV: Bad results with failure or ankylosis.

Groups I and II represent very satisfactory results. Of the 116 hips, 95 or 81.9 per cent. were included in these two groups. Some of the patients in Group III may recover better motion in the course of time. The stiffness which develops after postoperative arthritis or epiphysitis sometimes disappears very slowly,—as long as three years in some cases.

C. *Age of the Patient*

When one considers the results after primary open reduction according to the age of the patient, it is clear that the results are better when the child is under three years of age. On the contrary, the proportion of epiphysitis is higher in patients under two years of age. For this reason, between two and three years of age was selected as the most favorable period for open reduction.

Such a proportion of good results after open reduction is very interesting because, of the 116 hips, forty-eight patients had unilateral operation and thirty-four patients had bilateral operation. The number of bad results formerly recorded after closed reduction for bilateral luxation of the hip are well known.

FIG. 6-A FIG. 6-B

Fig. 6-A: Case T. U.; patient, thirteen and one-half years of age, had unilateral luxation. Open operation was by the Zahradníček technique.
Fig. 6-B: Two years after operation, motion poor.

FIG. 7-A FIG. 7-B

Fig. 7-A: Case L. Patient, thirteen years old, had a unilateral luxation.
Fig. 7-B: Open reduction, with shortening of the femur, was carried out according to author's method.

II. *Results after Open Reduction with Shortening of the Femur*

Of ninety-five dislocations, eighty-one occurred in children between three and fifteen years of age. Fourteen occurred in individuals between fifteen and thirty-three years of age. In the young people (eighty-one cases), a fair reduction was obtained in sixty-three cases (77 per cent.). The bad results in the remaining eighteen cases were as follows: Eight had ankylosis, three had a high degree of coxa vara, and seven had some degree of necrosis of the head. The results as regards motion are as follows:

Group I	Fourteen cases
Group II	*Sixteen cases*
Group III	Forty-three cases
Group IV	Eight cases

The good results (Groups I and II) are to be found only in young patients. In the course of time, the acetabulum becomes narrow and must be excavated in order that a good reduction may be obtained. Such a manoeuvre sets adhesions which leave the joint stiff. This stiffness reaches its highest degree in adults.

Of the fourteen adults, reduction was satisfactory in thirteen. In the one bad result, necrosis of the head developed. In contrast to these anatomical results, the degree of motion was very poor. Nine cases fell into Group III and five cases into Group IV. In other words, there was not a single satisfactory result.

For this reason, operation for bilateral dislocation is advocated only in children under six years of age. In older patients, the author performs open reduction only for unilateral luxation. In this kind of open reduction, the head finds a secure support in the acetabulum and the joint retains a few degrees of motion in about two-thirds of the cases.

During the last six months the author has tried to maintain a higher degree of motion by keeping the capsule around the head of the femur, according to the Colonna technique. This is a very interesting operation, especially for adults with high dislocations of both hips.

III. *Results in Open Reduction after Reluxation and Secondary Subluxation*

In this group of cases the joint has been badly damaged by previous manoeuvres of closed reduction. At operation one always finds many adhesions in the joint, many ulcerations of the cartilaginous covering of the head, a wearing out of the acetabulum, and a severe degree of epiphysitis.

The results are evidently not so satisfactory as after primary open reduction, but they

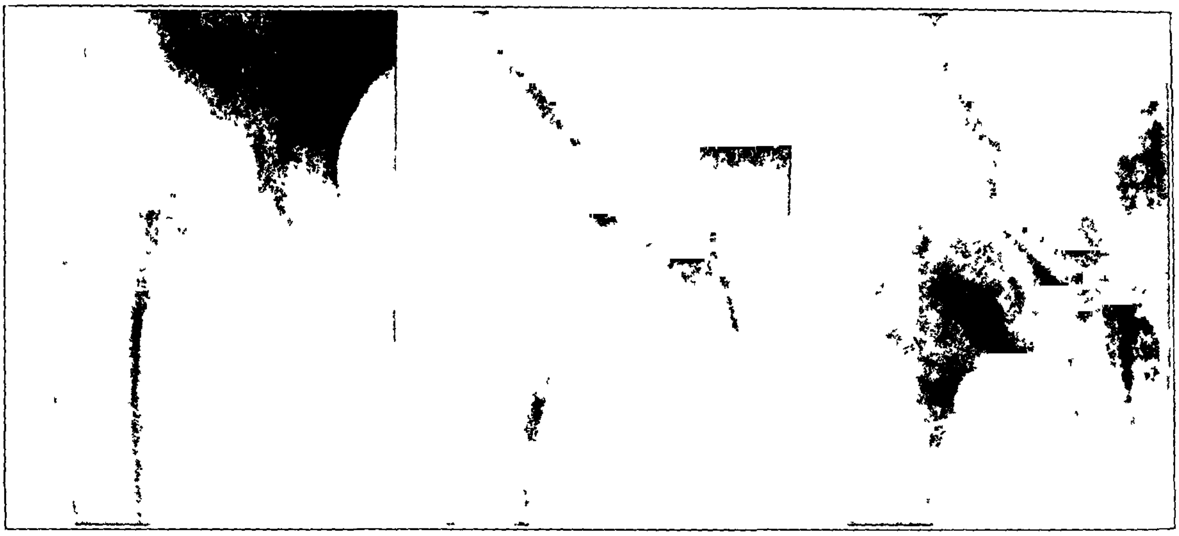


FIG. 8-A FIG. 8-B FIG. 8-C

Figs. 8-A and 8-B: Case T. A. Patient had unilateral luxation with closed reduction at the age of five and one-half years.
Fig. 8-C: Arthrogram shows residual subluxation, two years after the reduction.

FIG. 8-D FIG. 8-E

Fig. 8-D: Results three years after secondary open reduction. Motion is normal.
Fig. 8-E: Huge interposition of fibrous tissue removed at the time of secondary reduction.

are good enough to justify an operation. Of 102 cases, fair reductions were obtained in eighty-two. The bad results consisted of five reluxations and fifteen permanent subluxations, which one cannot always reduce by a secondary operation. Severe epiphysitis existed in thirty-five cases, but this had developed before the open reduction.

Nevertheless, the results are sometimes very satisfactory. Good motion (Groups I and II) resulted in fifty-three cases or 51.9 per cent. Poor motion occurred in forty, and complete stiffness in only nine cases.

COMMENT

It would certainly be better to avoid reluxations and secondary subluxations. That is why it is absolutely necessary to check the reduction, by means of arthrography, in all cases of congenital dislocation of the hip. Then one can verify that it is impossible to obtain a good result in true luxation without primary open reduction.

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OCCURRENCE AND MANAGEMENT OF REFLEX SYMPATHETIC DYSTROPHY (CAUSALGIA OF THE EXTREMITIES) *

BY JAMES W. TOUMEY, M.D., BOSTON, MASSACHUSETTS

From the Department of Orthopedic Surgery, the Lahey Clinic, Boston

Reflex sympathetic dystrophy is a disturbance of the sympathetic nervous system, characterized by pain and sympathetic phenomena which may follow major or minor traumata.

The term "causalgia" was first used by Mitchell, Morehouse, and Keen at the time of the Civil War, when causalgia was so brilliantly described by them. "Reflex dystrophy", used by de Takáts [1], embraces a wide range of related conditions,—from the relatively mild post-traumatic dystrophies, characterized by moderate pain, with sweating and changes in the color of the skin, to the agonizing torments of the major causalgia.

The most prominent feature of reflex sympathetic dystrophy is chronic, continuous, burning pain. Characteristic sympathetic phenomena also appear, the most common of which is vasoconstriction, which causes whiteness or blueness of the affected extremity. Conversely, there may be vasodilatation, with redness of the extremity. The objective signs which indicate the syndrome of reflex sympathetic dystrophy are coldness, increased sweating, skin-color changes—usually pallor or cyanosis—and swelling of the extremity. In the advanced cases, the hand or foot is puffy, with enlarged, stiff joints not unlike those of rheumatoid arthritis. The skin becomes atrophic, smooth and thin, with loss of wrinkles; and the nails become ridged. Roentgenographic examination of the bones shows generalized or spotty decalcification, known as trophic osteitis or Sudeck's bone atrophy.

In articles on post-traumatic sympathetic dystrophy, there has been an enormous confusion of terms, which has prevented simplification of the issue. Leriche, who has contributed much to the study of pain, through the experience of more than 1200 sympathectomies, referred to this syndrome as the "post-traumatic ascending neuralgias". Livingston [8] used the term "post-traumatic pain syndrome". Homans has described the minor causalgias. The following terms were used in describing the thirty-one cases studied in this series: "reflex sympathetic dystrophy", "causalgia", "minor causalgia", "post-traumatic pain", "traumatic sciatica", "sympathetic phenomena post-traumatic", "Sudeck's atrophy", and "nerve injury". Thus, an effort has been made to describe the same syndrome by a large group of heterogeneous terms.

Because of this confusion, the author considers it worth while to bring this study to the attention of orthopaedic surgeons, who usually treat the injury in the first place, and are therefore concerned with the possible preventive treatment of sympathetic dystrophy. Although orthopaedic surgeons may not perform the sympathectomies, they should be conversant with this syndrome.

The pain may come on directly after the injury and never abate, or it may commence weeks or even months after the injury has occurred. The distribution of pain does not usually follow the peripheral nerves, but tends to spread throughout the hand, foot, or even the entire extremity. There is no definite clinical picture. The demarcation line between the cerebrospinal pain following trauma and the later complicating pain of causalgia cannot be clearly drawn. Reflex sympathetic dystrophy appears unexpectedly, frequently after a very mild trauma, such as an ordinary sprain of the ankle, or even after a minor contusion. The initiating traumata in this series of thirty-one cases are shown in Table I.

It is of particular significance to the orthopaedic surgeon that this condition is so

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 26, 1948.

TABLE I

INITIATING TRAUMA IN THIRTY-ONE CASES

Initial Trauma	Number of Cases
Fracture of ankle	3
Other fractures	6
Sprain of ankle.	3
Other sprains	2
Primary nerve injury	3
Injury after injection of drug	3
Contusion	3
Contralateral phenomena	2
Crushing injury	2
Spontaneous injury	1
Arterial thrombosis .	1
Hemiplegia.	1
Injury after removal of bone tumor	1
Total . .	31

frequently caused by fractures and sprains. Attention may be drawn to a dystrophy when a patient is not moving his joints normally after a trauma, and when he cannot tolerate any form of physiotherapy because of aggravation of pain.

In all of the thirty-one cases reviewed (Table II), the condition was ultimately severe enough to require sympathectomy; it may also be noted that any injury to the extremities, even operative trauma, may have as its sequel a reflex sympathetic dystrophy severe enough to warrant sympathectomy. Nerve injury and blood-vessel injury are notorious causes of reflex dystrophy, but are not outstanding in this series of cases, for in civilian life these injuries are not seen so frequently as they are in wartime surgery. Crushing injuries are notably painful, slow in recovery, and may lead to sympathetic dystrophy. In this series, the author could not find any typical chain of circumstances which produce reflex dystrophy. Some of the patients were adequately treated from the beginning by competent orthopaedic surgeons. In other patients, the injuries, especially ankle sprains, were neglected, some of the fractures were immobilized for too long a time, with the cast extending over the ends of the fingers. It is possible that both undertreatment, or allowing an injured extremity to function very painfully, and oversplinting, or permitting disuse atrophy and stiffness, particularly in older people, predispose to sympathetic dystrophy. More important still, it would seem that it is the vasomotor temperament of the individual, rather than the trauma itself, which tends to produce the sympathetic dystrophy. Obviously, in the great majority of patients who are undertreated or overtreated, reflex dystrophy does not develop. Leriche emphasized the point that it is the vasomotor nature of the individual, rather than his mental reaction, which leads to sympathetic dystrophy; and Mayfield and Devine, in a psychiatric study of patients with causalgia, noted that they were found to be normally stable.

It is the author's belief that the spontaneous lessening of causalgic pain is the exception rather than the rule. Not only does the intensity of the pain increase, but it has an ever-widening distribution. Lapse of time does not seem to produce cure. Pain should not always be considered a valuable warning of a serious pathological condition, or a protection to the body; but, as Leriche stated, pain may be a baleful gift. The agonizing pain of causalgia fills the patient's entire life and consciousness and brings about serious personality changes. In the cases of severe dystrophy, pain appears to create more pain, both in degree and in extent.

DIAGNOSIS AND TREATMENT

The diagnosis and treatment of reflex sympathetic dystrophy should be discussed at the same time because the local injection of procaine is the key to diagnosis, and may also effect a cure when used peripherally or to block the sympathetic ganglia. In cases of reflex sympathetic dystrophy, small, frequently multiple, excruciatingly tender areas, or "trigger points", are usually found in the affected extremity. These areas are more tender than any of the surrounding structures. In our experience, the direct attack on these "trigger points" with repeated injections of procaine was usually unsuccessful in relieving pain, and could not be compared in efficacy with the definite success achieved by local procaine block. The injection of procaine in trigger areas, however, may have value in the milder, more localized cases of dystrophy.

After the presumptive diagnosis of reflex sympathetic dystrophy has been made from the patient's history and from the physical and roentgenographic findings, the patient is admitted to the hospital; procaine block of the appropriate segments of the sympathetic chain is then carried out. This may be either of the stellate ganglion, or the second and third thoracic ganglia, or a paravertebral sympathetic block. The technique has been described by Volpitto and Risteen, Nicholson, and many others. The proper selection of patients for sympathectomy would be impossible without observation of the diagnostic effect of the block, since the signs and symptoms of the syndrome are clear-cut in only a few cases. The general statement may be made that patients who obtain little or no relief from a block will obtain little or no relief from sympathectomy; the reverse is also true to a lesser degree.

Evans emphasized the importance of the diagnostic procaine block. The dramatic, rapid relief of chronic pain, often of years' duration, which is afforded by a few cubic centimeters of procaine, is a phenomenon which is never forgotten after it has once been seen. This procedure has opened a new door in the treatment of pain. A few drops of procaine may free the patient from the tyranny of pain which had existed for years.

One of the chief difficulties in the evaluation of the efficacy of the block is the suggestibility of the patient himself. If it is suspected that the patient is unduly susceptible to suggestion, the block should then be repeated with saline solution instead of procaine. Some patients with the milder forms of causalgia, as suggested by Homans, may be relieved by one or a series of procaine blocks. Homans emphasized the prevalence of minor injuries as etiological agents, especially the puncture injuries of splinters, thorns, and the bites of animals. Leriche described a classical case of causalgia produced by a bone-splinter wound, sustained while the patient was dressing a rabbit, in which the causalgia was completely relieved by repeated procaine blocks alone.

The procaine blocks in this series were carried out in the Department of Anesthesiology under the direction of Urban H. Eversole, who stressed the following points:

1. A single negative block should not be accepted as diagnostic, since there is the possibility that the ganglion may have been missed.

2. False-positive results from block may be due to the effect on peripheral nerves; therefore, small amounts of procaine should be used for a diagnosis.

3. There should be positive evidence of a successful block, such as Horner's syndrome; the success of a lumbar block is very doubtful if it does not produce at least a slight rise in temperature.

This study was based on thirty-one patients with reflex sympathetic dystrophy, treated by sympathectomy, who were seen at the Lahey Clinic from July 1944, to July 1947. During this same period, 337 sympathectomies were performed, for all causes, demonstrating that this series of cases with reflex sympathetic dystrophy constitutes a relatively small proportion of the total number of sympathectomies performed. Nearly all of these operations were performed on the Neurological Service. The technique of sympathectomy has been described by de Takáts [2], Smithwick, Pearl, and White.

TABLE II

REFLEX SYMPATHETIC DYSTROPHY—SUMMARY OF THIRTY-ONE CASES

Case No.	Age and Sex	Original Trauma	Interval before Sympathectomy	Signs and Symptoms	X-ray Findings	Sympathetic Block (Location and Results)	Sympathectomy	Interval after Sympathectomy (*Months*)	Results
1	34 F.	Fractures of fourth and fifth metacarpals; splinted for 3 weeks	9 months	Extreme pain. Trigger point in fifth finger. Hand cold, red, cyanotic.		Cervical. Increased temperature; pain relieved.	Right thoracic	2	Pain relieved. Skin warm and dry. Finger function increased.
2	41 F.	Sprain of right ankle; treated with strapping, cast, then brace	6 years	Extreme pain. Atrophy of left calf. Trigger point in sinus tarsi. Foot cold, white.	Decalcification	Right paravertebral. Pain relieved for 2 hours; increased heat; improved color.	First, second, and third lumbar	6	No relief from pain until after subtalar arthrodesis
3	32 F.	Injection of local anaesthetic at elbow for operation of hand	15 months	Extreme pain. Atrophy of hypothenar eminence. Fourth and fifth fingers flexed. Ulnar paralysis.		Cervical. Complete relief from pain in 5 minutes.	Right thoracic (May 1945). Second and third thoracic ganglia. Ulnar nerve explored (Oct. 13, 1944).	5	Unimproved. Ulnar paralysis remained.
4	29 F.	Injury to foot after kicking door of automobile	1 year	Dull, persistent pain in entire leg. Foot cold. Ecchymosis and pain in instep. No pallor, redness, sweating, or trigger points.	Negative	Right lumbar paravertebral. Relief from pain.	Right lumbar (first through fourth ganglia)	8	Complete relief for 2 months only
5	40 M.	Multiple injuries from car accident (May 1946). Fracture of left radius; splinted for 9 weeks.	9 months	Extreme pain in left arm and hand. Hand cold, white. Wrist and hand absolutely stiff. Profuse sweating.	Healed fracture of left radius (Jan. 1947)	Cervical. Pain relieved; skin warm and dry; motion increased.	Left thoracic (second and third ganglia)	5	Complete relief from pain, blueness, and sweating. Function increased

6	62 F.	Right hemiplegia of 2 years' duration. Pain in right leg for 21 months.	2 years	Pain in right foot, calf, and knee. Foot cold with waxy pallor. No sweating.		Right lumbar. Temporary relief from pain in first 3 toes.	Right lumbar (second through fourth ganglia)	8	No relief
7	12 M.	Right arm cut above elbow by glass	11 months	Pain in ulnar and medial portions of arm. Muscle weakness. Fingers numb, swollen, red, and cold.		Right thoracic. Relief from pain with increase of radial pulse.	Right thoracic	5	Complete relief from pain. Sensation returning; hand warm and dry.
8	39 M.	Injury to right elbow after fall from ladder	8 years	Pain in entire hand and arm, increased with motion. No color change or sweating.		Stellate ganglion. Four blocks performed, all with complete transient relief.	Right thoracic (second and third ganglia)	34	No relief from pain
9	27 F.	Minor injury to left leg, with foot-drop. Congenital syphilis.	4 months	Pain, weakness, and coldness in left leg. Quadriceps and foot extensors weak. No ankle reflex.	Mottled decalcification	Three paravertebral blocks, with transient improvement	Left lumbar (first through third ganglia)	39	Fair relief from pain. Excellent relief from coldness. Good functional improvement.
10	60 M.	May 1943. Traumatic amputation of fifth finger of left hand. (Right arm previously amputated.)	3 months	Severe pain in left hand one year later. No sympathetic phenomena.		Cervical. Relief from pain in fourth finger only.	Oct. 1944. Second and third thoracic ganglia	38	No relief. Patient unable to work.
11	19 F.	Sprain of left ankle	5 years	Pain, swelling, coldness in left foot and ankle. Atrophy of left calf. Trigger point in lateral malleolus.		Left lumbar. Relief for 6 hours.	Lumbar	8	All symptoms and signs completely relieved. Short relief from trigger-point injection.

TABLE II (*Continued*)

REFLEX SYMPATHETIC DYSTROPHY—SUMMARY OF THIRTY-ONE CASES

Case No.	Age and Sex	Original Trauma	Interval before Sympathectomy	Signs and Symptoms	X-ray Findings	Sympathetic Block (Location and Results)	Sympathectomy	Interval after Sympathectomy (*Months*)	Results
12	39 F.	Incomplete fracture of upper portion of humerus	14 months	Pain, coldness, and stiffness in right hand with pallor and increased sweating. Hand useless.	Decalcification	Stellate ganglion. Pain and coldness relieved; finger motion increased.	Right thoracic	15	Excellent. No pain. Patient able to type, and to clench fist completely.
13	35 M.	Partial sciatic paralysis after paraldehyde injection into buttock for acute alcoholism.	3 months	Pain, weakness, and atrophy of left leg with sensory changes. No ankle reflex.		Right paravertebral. Complete relief for 2 hours.	Left lumbar (first through fourth ganglia)	3	Complete relief from pain
14	34 F.	Knee twisted in fall; in cast 1 month	9 months	Pain and swelling in right knee. Skin of lower leg and foot blue. Foot cold. Trigger points in knee and foot.	Sudeck's atrophy	Second and third right lumbar. Relief from pain and increase in heat.	Right lumbar (first through third ganglia)	6	Complete relief from pain
15	64 M.	Injection of antisyphilitic drug outside vein at elbow	1 year	Fingers pale, cold, white; extreme pain. Wrist and hand stiff. Skin atrophic.	Spotty decalcification	Two stellate blocks, with transient relief from pain. Unsuccessful trigger-point injection.	Left cervical	5	Relief from pain. Inability to close hand completely.
16	39 F.	Four toes crushed by heavy piece of iron	14 months	Moderate pain in right foot. Foot cold and dark red when dependent.	United fracture of proximal phalanx of first toe	Paravertebral (second, third, and fourth lumbar ganglia). Relief.	First and second lumbar ganglia	3	Relief from pain

17	41 F.	Fracture-dislocation of right shoulder	3 years	Extreme pain in shoulder, medial distribution, from third day after accident to admission. Hyperaesthesia of medial and radial distribution.		Stellate ganglion. Partial relief from pain. Skin temperature raised.	Right cervical. Transient hyperaesthesia of right arm and breast after sympathectomy.	8	Moderate pain in all fingers except ulnar distribution. Good improvement in function.
18	31 F.	Fracture of right wrist. Wrist and fingers splinted tightly for 12 weeks.	14 months	Moderate pain, coldness, greatly increased sweating, cyanosis of hand. No trigger zones. Radial pulsation decreased.	Osteoporosis. Old healed fracture.	None	Right thoracic (first through third ganglia)	17	Good relief from pain and swelling. Excellent relief from coldness. Fair increase of function.
19	25 M.	Right lower leg crushed by heavy box	3 years	Severe pain; moderate swelling, coldness, and sweating. Skin red. Arteries of foot not felt.	Arteriosclerosis	Caudal anaesthesia. No relief from pain.	Right thoracic (twelfth thoracic through third lumbar ganglia)	32	Excellent relief from pain, coldness, sweating. Good relief from swelling. Improvement of function.
20	30 M.	Spontaneous onset of pain and swelling in right foot. Unrelieved by high thoracic chordotomy.	5 years	Severe pain. Atrophy in right calf. Foot stiff. Normal arterial pulsations.	Osteoporosis	Second through fourth lumbar. Dramatic relief from pain.	Right lumbar (first through fourth ganglia)	44	Unimproved. Constant pain.
21	49 F.	Questionable fracture of left hand after fall. Cast for 1 weeks.	11 months	Extreme pain in wrist and hand. Fingers warm, pink, oedematous, shiny. Finger motion 50 per cent.	Bone atrophy	Left cervical. No relief.	Left thoracic (second and third ganglia)	16	Good relief from pain in wrist and hand. Transient shoulder pain.

TABLE II (*Continued*)

REFLEX SYMPATHETIC DYSTROPHY—SUMMARY OF THIRTY-ONE CASES

Case No.	Age and Sex	Original Trauma	Interval before Sympathectomy	Signs and Symptoms	X-ray Findings	Sympathetic Block (Location and Results)	Sympathectomy	Interval after Sympathectomy (*Months*)	Results
22	30 F.	Left hand cut when soda bottle exploded. Surgical repair of laceration.	5 months	Extremely painful, cold, blue, stiff hand. Skin fine, glossy. Moderate sweating.	Marked atrophy	None	Left thoracic (second and third ganglia)	18	Good relief from pain and sweating. Fair relief from cold. Good increase of function.
23	29 M.	Avulsion of brachial plexus in motorcycle accident	27 months	Moderate pain and partial paralysis	Healed fracture of clavicle	None	Left thoracic (second and third ganglia). Brachial plexus explored. Scaleniotomy.	8	Complete relief from pain. Slight improvement in function.
24	40 F.	Right hand lacerated on dorsum when plunged through window	12 months	Deep, throbbing pain in arm. Pallor, cyanosis, numbness, and increased sweating of hand. Finger function 50 per cent.	None	Cervical. No relief from pain; arm became warm and dry.	Right thoracic (second and third ganglia)	39	Only relief some decrease in sweating. Multiple trigger areas. Case in litigation.
25	42 F.	Fracture of right ankle; in plaster for 7 weeks	4 years	Extreme pain in ankle; moderate swelling	Negative	Two lumbar blocks. No relief.	Right lumbar	29	No relief from pain or sweating; no increase in function. Unsuccessful trigger-point injection

26	22 M.	Fracture of right ankle in motorcycle accident. Traction for 2½ weeks. Patient walked in plaster at 6 weeks.	29 months	Pain in leg. Foot rigid, everted, tender, and blue.	Old fractures of calcaneus and navicular	Right lumbar. Relief from pain.	Right lumbar	1	Pain relieved
27	11 M.	Spontaneous pain in right arm. (Left arm amputated 20 years before.)	1 year	Pain in entire right arm. Increased sweating of hand.	Negative	Two right stellate blocks, partial relief from first, complete relief from second	Right thoracic (second and third ganglia)	2	Complete relief. Patient working.
28	15 M.	Right elbow struck by rifle bullet while patient was hunting	50 days	Right hand numb, pale, cyanotic, swollen. Median and ulnar nerve injury. Patient unable to make fist.	Metallic foreign bodies at elbow	None	Right thoracic. Neurolysis of median nerve; resection of ulnar nerve and neuroma; anastomosis.	36	Good relief from pain and coldness. Excellent relief from sweating.
29	51 M	Removal of "bone tumor" from foot (probably exostosis)	6 months	Pain, swelling, tenderness, stiffness of right ankle and foot. Pain and redness on dependency. Foot cold.	Negative	Right paravertebral (second through fourth lumbar), 70 per cent relief	Right thoracic (first through third ganglia)	38	Fair relief from pain and swelling. No relief from coldness. Fair improvement of function.
30	22 F	Sprain of right ankle with marked swelling	11 months	Swelling, redness, and pain of right ankle. Atrophy of calf. No change in sweating	Mottled atrophy	Right lumbar. Good relief from pain.	Left lumbar (first through third ganglia)	11	Excellent relief from symptoms. Excellent function.
31	45 F	Arterial thrombosis in left leg after delivery, 22 years before, fourth toe amputated	22 years	Moderate swelling and pain of foot. Skin bluish, shiny, cold. Ulceration of fifth metatarsophalangeal joint. Trigger zones present. Atrophy of left calf	Bone atrophy		Left lumbar	11	No relief from pain or coldness. Fair relief from swelling. Good relief from sweating and good improvement of function.

The results in this series were: good to excellent in twenty cases, fair in two cases, and poor in nine cases. In every case the coldness, blueness, and increased sweating were relieved by sympathectomy; but relief from pain was not uniform. At the time of sympathectomy, the oldest patient was sixty-four years of age and the youngest was nineteen. Of the four patients who were sixty years of age or older, a good result was obtained in only one, whereas good to excellent results were obtained in the four youngest patients, thus indicating that the results of sympathectomy are better in the younger age groups.

The average time which clapsed between injury and sympathectomy was thirty-two months, a surprisingly long period; this average excluded two cases of twenty and twenty-two years' duration.

There were eighteen females and thirteen males in this series. Fifty-five per cent. of the females and 70 per cent. of the males had good to excellent results, indicating that males appear to be a better risk for sympathectomy. Good or excellent results were secured in approximately two-thirds of the patients upon whom sympathectomies were performed.

A correlation was made between the duration of symptoms and the results of sympathectomy. It seemed that, in the cases with a longer history of symptoms and well-worn pain pathways, the patients did not respond so well after sympathectomy as did the patients whose symptoms had been of shorter duration. The interval between the onset of symptoms and sympathectomy averaged eighteen months in the "good-to-excellent" group, and thirty-five and one-half months in the "poor" group. Therefore, it can be definitely said that the prognosis is better in patients who have not had reflex sympathetic dystrophy for a long period of time. Leriche pointed out the many harmful side-effects of pain, and advised not waiting too long before sympathectomy is done.

In this series, the numbers of upper extremities and lower extremities involved were approximately equal, and there was no significant difference in the number of good results obtained after sympathectomy in these groups. The blocks accurately forecast the relief to be obtained by sympathectomy in all but four of the cases in the series. It is significant that, in general, a good block ensures a good operative result. In the four exceptions, all of the patients had had good blocks, but showed poor operative results. In two of these cases, the lower extremity was involved, and in two, the upper extremity. In every case in which there was a fair or poor block, the operative result was fair or poor.

The average period of time between the sympathectomy and the last examination was nineteen months; the shortest period was two months, and the longest forty-four months.

Two patients illustrated the tendency of a causalgic state to be transferred into the opposite extremity. Each of these patients had had an upper extremity amputated many years before. In one patient, who did heavy manual labor, a severe reflex sympathetic dystrophy developed in the remaining upper extremity, with spontaneous onset. This was satisfactorily relieved by sympathectomy. In the second of these amputees, causalgia developed in the remaining upper extremity after traumatic amputation of the fifth finger. This patient received partial relief from a block, and no relief from a sympathectomy. Three years after sympathectomy, he reported that he still had pain in his arm, and that he had had to give up working.

Sympathectomy was done in 75 per cent. of our cases. It is the author's opinion that sympathectomy should be done, even when the result of sympathetic block is not satisfactory, if the typical objective sympathetic phenomena are present. A borderline case, in which the diagnosis of reflex sympathetic dystrophy is not clear-cut, and in which the results of sympathetic procaine block are unsatisfactory, will show a poor result from sympathectomy.

Etamon chloride, instead of the procaine sympathetic block, has been used by James A. Evans at the Lahey Clinic in treating several patients. The results in these patients were satisfactory, and they were discharged without sympathetic surgery. Our experience is not extensive enough, however, to formulate an opinion regarding this drug.

The importance of active use of the extremity, as a valuable means of breaking the reflex, must not be forgotten. Before the value of blocks and sympathectomies, in the treatment of reflex sympathetic dystrophy, was appreciated, these patients were treated with carefully controlled physiotherapy, particularly active exercises and insistence upon active use of the extremity. In general, it may be said that the patients who were able to cooperate with the program gradually improved. Function increased, atrophy of soft parts and decalcification of bone lessened, and pain diminished. The road was a long and hard one for patient and surgeon alike. Sympathectomy has proved to be a short cut to cure in many of these cases: nevertheless, after sympathectomy, it is of paramount importance that physiotherapy be instituted, especially in the form of active exercises, for the rehabilitation of stiff joints and atrophied muscles.

Although good to excellent results were obtained in relieving the pain in two-thirds of the patients with sympathetic reflex dystrophy upon whom sympathectomies were performed, the need for further study of this problem is evident. Pain is a dynamic force,—a veritable flood which will seek outlet by every possible means. The neurosurgeon gradually has developed an armamentarium of means to block the pathways of pain, but the problem is not yet completely solved. It must be emphasized that sympathectomy is not a cure-all for dystrophies.

Peripheral-nerve section, in general, is unsatisfactory. It may continue from eighteen months to two years, but some patients obtain relief for only two or three months after this procedure. Rhizotomy has largely been discontinued because of the poor operative results. Spinal chordotomy has serious disadvantages in its effect upon the bladder and rectum, and also in the possibility of incomplete relief from pain and of pain in new locations. Periarterial sympathectomy still has a place in certain cases, as Leriche reported.

At present, sympathectomy is by far the best operative procedure for the treatment of reflex sympathetic dystrophy; in addition to sympathectomy, however, the underlying cause of the pain must be corrected, as has been demonstrated in two of the cases in which arthrodeses were performed.

PREVENTIVE TREATMENT

The underlying principle in preventing the occurrence of reflex sympathetic dystrophy is to treat the trauma so that painless function of the extremity is restored in the quickest possible time. During all phases of recovery, it is important to prevent the patients from having pain. The author believes that the modern tendency to use procaine locally in the treatment of sprains is an excellent one, and that its use should be widened. In the treatment of fractures, it is important to look for any injuries, however slight, which may affect blood vessels or nerves. If any sympathetic phenomena are noted, a procaine block should then be done; if indicated, a series of blocks should be performed. Overtreatment of fractures is dangerous; splinting should not be continued too long and function of the extremity must be encouraged. Local injections of procaine and procaine blocks, as adjuvants to the early treatment of trauma, will lessen the incidence of reflex sympathetic dystrophy.

SUMMARY

In thirty-one cases of reflex sympathetic dystrophy, patients were treated by sympathectomy at the Lahey Clinic, from July 1944, to July 1947. The average postoperative follow-up period was nineteen months. Fractures and sprains were the inciting causes in one-half of the cases in this series.

The diagnosis rests on the clinical picture of sympathetic phenomena, which include: coldness, skin-color changes, increased sweating, swelling, and atrophy of skin and bone, *plus* the relief of pain, sweating, and coldness by procaine sympathetic blocks.

Sympathectomy is justified if good, but not permanent, results are obtained by the

procaine sympathetic blocks. Sympathectomy can be relied upon to relieve the sympathetic phenomena; this procedure relieved the pain in two-thirds of our cases.

Surgery, such as arthrodeses of painful joints, may be required, together with sympathectomy, to effect a cure.

In this series, the best results were achieved in those patients who had had reflex sympathetic dystrophy for relatively short periods, and those who were in the younger age groups.

If the result of the block is poor, the result of the sympathectomy will also be poor. Even though the result of the block is good, the result of sympathectomy will not be good in all cases.

The prevention of reflex sympathetic dystrophy depends upon treating traumata so that pain is minimized and function is restored to the extremity as rapidly as possible.

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DISCUSSION

DR. J. E. M. THOMSON, LINCOLN, NEBRASKA: Dr. Toumey has covered thoroughly the various aspects of this subject with respect to etiology, recognition, and treatment. The early recognition of potential causalgia and the care given after severe and minor injuries of the extremities cannot be overemphasized.

In my opinion, the definite presence of local shock, vasomotor deficiency, coldness, pallor, or extreme swelling is sufficient to justify paravertebral procaine block of the controlling sympathetic mechanism, with perhaps local procaine infiltration.

The decision to perform a sympathectomy must be made early, if it is to be effective and to prevent chronic symptomatic and objective changes in the extremity. The response to paravertebral block forms a good criterion as to what may be expected from a sympathectomy.

One point that I would like to stress is the importance of the control of pain in early or late cases of causalgia and neuralgia, in obtaining an estimation of the progress and course of the condition. In 1931,

(Continued on page 907)

ARTHRITIS DEFORMANS OF THE HIP JOINT AND ITS PATHOLOGICAL HISTOLOGY

Research in Polarized Light

BY PAOLO E. LUGIATO, M.D., BERGAMO, ITALY

From Istituto Ortopedico Matteo Rota, Bergamo*

Much is known of the pathological anatomy of arthritis deformans in general, and of the hip joint in particular. The essential alterations are traumatic in origin and include degenerative and proliferative changes, erosion of the cartilaginous and superficial bony strata, and loss of elasticity of the joint components.

Degeneration, proliferation, and erosion are most evident on macroscopic examination; and, in the more advanced stages, the loss of cartilage elasticity is apparent.

Alterations of the fibrillar framework of the cartilage result directly in loss of elasticity. These changes appear late in gross and histopathological preparations, stained by the common laboratory methods. By the polarized-light technique employed in this study, these fibrillar alterations are shown to appear early and to determine the sequence of these well-known anatomicopathological changes. To demonstrate this, the author has carried out parallel studies of stained preparations and of similar unstained sections, examined by means of polarized light. A technical description of the polarized-light method seems unnecessary, since it may be found in any good textbook on the subject.

For a satisfactory understanding of the descriptions of the pathological material included in this work, it is necessary to know the appearance of the normal joint tissue.

Fig 1-A

Fig 1-B

Fig 1-A Cross section of normal femoral head, stained with hematoxylin-eosin The cartilage layer is of uneven thickness, the ground substance is stained deeply, the cartilaginous cell groups increase in number and size from surface to depth The osteocartilaginous boundary is clear, continuous, and wavy in outline Subchondral bone of moderate thickness is continuous with the cartilage and the underlying spongy bone

1, Superficial layer *2*, radial layer, *3*, osteocartilaginous boundary, *4*, subchondral bone

Fig 1-B Same case Unstained preparation in Canada balsam, examined in polarized light with Nicol's prisms crossed to 90 degrees Polarization plane indicated at the bottom Surface layer appears as the bright strip at *1* The darkened layer beneath contains the curvilinear fibers, invisible on the photomicrograph, at *2* Bright radial fibers appear at *3*, interspersed by cellular groups in mosaic patterns and by invisible cross fibers Note bright birefringent pointlike nuclei The osteocartilaginous boundary appears at *4* as a continuous binding zone, visible as such because of difference in brightness Subchondral bone is hardly visible, being in a plane of polarization different from that of cartilage

Birefringent cell nuclei and collagenous fibers, as seen in this illustration, are not always visible in the same plane of polarization It is often necessary to set the plane of polarization at a different angle in such cases the fibrillar structures may fade away and the nuclei may appear very neat (*Reproduced by permission, from Chir d Org di Movimento*[2])

* Prof Dr R Marziani, Director

as stained by commonly employed methods, on the one hand, and as seen in polarized light [1,2,5,6], on the other. Two photomicrographs of sections of a normal femoral head are shown to clarify the exposition. The first (Fig. 1-A) is stained with hematoxylin-eosin, and shows a cross section of the cartilage and superficial bony layers of a normal adult femoral head. The second (Fig. 1-B) shows the same tissues in polarized light. In Figure 1-B the unstained section has been embedded in Canada balsam and is viewed through a polarizing microscope (using crossed Nicol's prisms, in an optic sector of maximum brightness).

FIG. 2-A

Early changes include fraying of the surface layer, *1*, which is irregular; lack of uniformity in thickness of cartilage; spotted staining of ground substance; uncertainty of osteocartilaginous boundary; and thinning of bone trabeculae.

FIG. 2-B

Same case in polarized light. Normal birefringent fibrillar systems are changed into coarse groups in the upper portion. Note total irregularity of the arrangement. In the lower portion, the arrangement is still well preserved. Binding line is scarcely visible, being broken in many places. The continuity of the fibrillar systems is broken in extensive areas, especially in the left upper portion of the illustration.

HISTOPATHOLOGICAL CHANGES

One of the first alterations to be seen under the microscope is the fraying of the cartilage surface layer, the uniformity and smoothness of which are being lost. In cross section there is irregularity of surface outline, slight at first but becoming more marked as degeneration progresses (Fig. 2-A). The superficial layers may be elevated or partially exfoliated, causing unevenness of depth of the cartilaginous covering of the bone. The ground substance of the radial layer is irregularly thickened and is stained very unevenly. Less distinct is the boundary between bone and cartilage, and in places this line has disappeared. The subchondral bone is also irregularly thickened, presumably in order to compensate for the diminished resistance of the cartilage.

The normal birefringent fibrillar system loses its regular distribution (Fig. 2-B), being disposed in irregular coarse blocks in some places, while in others it remains unchanged. There may even be disappearance of entire bundles of birefringent fibers. During these early phases, changes in the other histological components are faintly perceptible.

Penetration of vessels into the deeper cartilage

layers may rapidly follow fraying of the surface layers, through breaches in the osteocartilaginous boundary. Hemorrhage, fibrin deposits, and scar tissue appear in rents formed in the frayed portions (Fig. 3-A). It will be seen further that the fibrin deposits give rise to microcysts. With the erosion of the surface layer begins the progressive reduction in the number of cartilage cells.

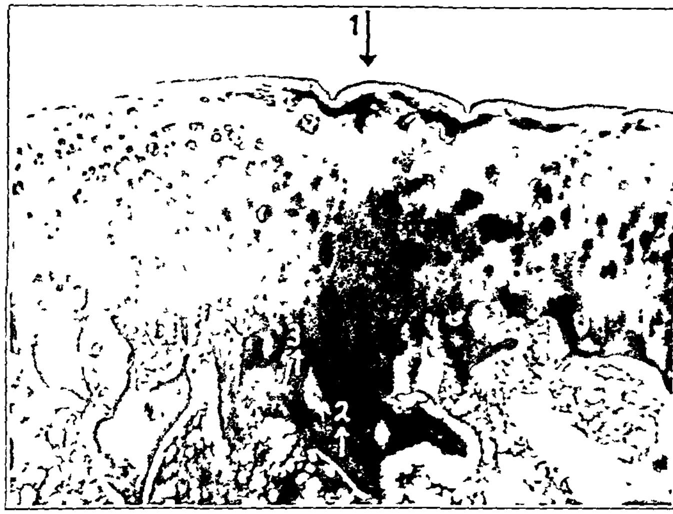

FIG. 3-A

Fibrin deposits appear between the surface and intermediate layers of cartilage (*1*). There is a tendency to reduction in the number of cartilage cell groups (*2*). Osteocartilaginous boundary is broken and disappearing (*3*).

Birefringent collaginous *fibrils greatly diminish in* number and unite to form large supporting systems, having a radial distribution, apparently designed to prevent the progressive destruction of cartilage. They are joined with the fibrillar systems of subchondral bone, apparently for reinforcement, and almost completely eliminate the optical boundary which separates these two systems in normal tissue (Fig. 3-B). Sometimes rearrangement of the normal fibrillar system into bundles produces highly intense light effects, indicating strengthening of the bundles (Figs. 4-A and 4-B), while all other parts lose their brightness because of a sharp reduction in the number of collaginous fibrils.

FIG 3-B

Appearance of fibrillar systems in polarized light. (Compare with Fig. 3-A.) Shows remarkable thinning of surface layer. Some columnlike fibrillar systems appear, contrasting with other, more weakly shining, systems (*1*). There is a tendency to mingling of cartilaginous and bony fibrillar systems, with fading of osteocartilaginous boundary (*2*). In this figure several pointlike nuclei appear, but are not surrounded by the birefringent fibrillar halo visible in the preparation of the normal tissue.

Where the cartilage has been lost through erosion, the exposed underlying bone is sclerotic and thickened. Soon the bone is covered with dense fibrous connective tissue, which reduces the erosion of the cartilage on the opposite joint surface (Fig. 5-A). In these areas the fibrillar system has disappeared with the cartilage. There is no trace of it in the dense connective tissue overlying the bone (Fig. 5-B). The remainder of the fibrillar system breaks up into small bundles and, little by little, is reabsorbed.

The erosion of cartilage is not always complete; often there is rapid thinning, marked loss of vitality, and absence of cartilage cells (Fig. 6-A). In adjacent portions the remaining cells may be seen in clusters, showing some loss of their normal characteristics, and

FIG. 4-A FIG. 4-B

Fig. 4-A: More advanced changes in polarized light. Some fibrillar, column-like systems are highly birefringent, while all others and those of the bone bed are scarcely visible.

Fig. 4-B: Cartilage remnant of acetabulum in polarized light. Big bundles of birefringent collaginous fibrils appear on the weakly shining background. The osteocartilaginous boundary has vanished. There is a thin layer of subchondral bone.

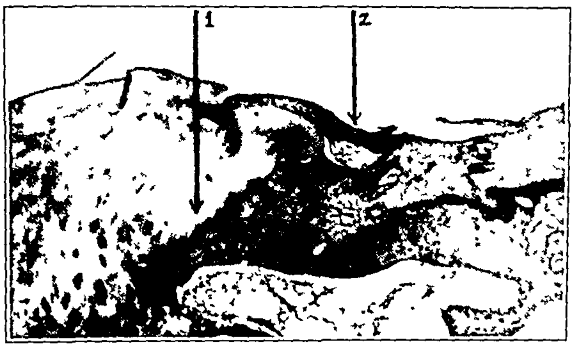

FIG. 5-A FIG. 5-B

Fig. 5-A: Eroded cartilage has been replaced by dense connective tissue; a small island of cartilage remains, undergoing absorption (*2*). Beneath, there is a thick layer of bone. At *1*, an osteocartilaginous zone is still partially preserved.

Fig. 5-B: Photomicrograph (reversed) in polarized light of a preparation similar to the preceding one. Abundance of birefringent fibrils may be seen in cartilage at right, with little change. Where cartilage is replaced by connective tissue, these are absent. White points are birefringent cellular nuclei and cross sections of collaginous fibrils.

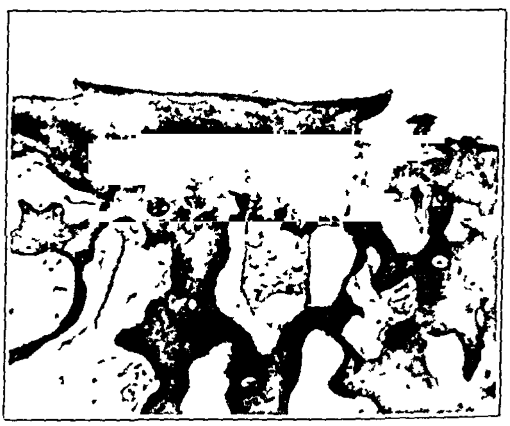

FIG. 6-A FIG. 6-B

Fig. 6-A: Abrupt reduction of thickness of cartilage is seen at the left, above. There is almost complete disappearance of cartilage cells at the right, and invasion of cartilage by connective tissue.

Fig. 6-B: Stage of erosion is far advanced. Marked reduction in thickness of cartilage, and replacement fibrosis. The osteocartilaginous limit is irregular. The subchondral bone is markedly sclerotic.

gradually the layer becomes invaded by dense connective tissue. The boundary between bone and cartilage disappears little by little (Fig. 6-B).

By the polarized-light method, it has been demonstrated in the foregoing that changes in arrangement of the collaginous fibrils appear very early in the evolution of arthritis deformans, and constitute the first signs of degeneration. When the ordinary methods of staining are employed, fibrils are apparent microscopically only in the very late stages of degeneration, when there has been extensive destruction of the cartilage layer. They are never visible in normal tissue stained by hematoxylin-eosin, and only exceptionally can they be demonstrated in pathological tissue, as in Figure 7-A.

Fig. 7-A

Hematoxylin-eosin preparation and high-power magnification. Collaginous fibrils may be seen in some places between the superficial and radial strata of the cartilage; normal collaginous fibrils cannot be revealed with this staining.

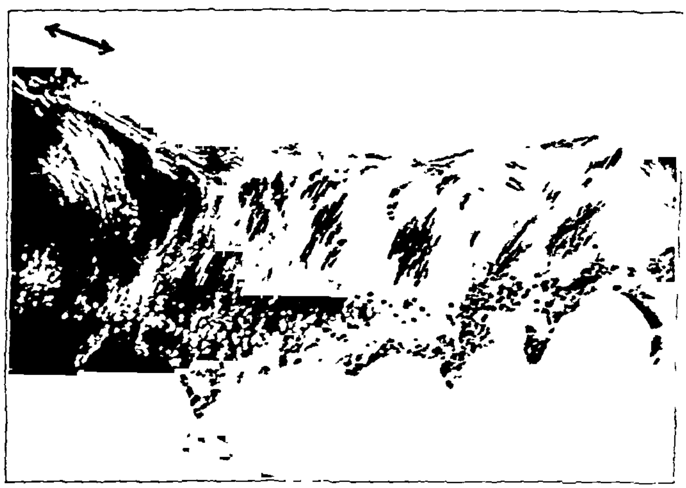

Fig. 7-B

Birefringent collaginous fibrils have almost wholly disappeared, except in a few areas, where they appear joined in slender bundles. Cellular nuclei are visible only in the narrowed layer of cartilage adjacent to the bone plate.

In the final stages of arthritis deformans, when compression and erosion have markedly thinned the cartilage, the number of birefringent collaginous bundles is greatly reduced, leaving slender, feebly shining groups of poor refringibility. The bony fibrillar system is thoroughly disorganized. Here also, the bundles are reduced in number and have almost lost their optical properties (Fig. 7-B). The Haversian systems are completely eclipsed. These changes are consistent with the gross changes of loss of brightness of the cartilage, its gray discoloration, and its softening.

The last stage of degeneration is characterized by the complete replacement of large areas of cartilage by dense connective tissue, which in places gradually disappears. In areas not subjected to pressure, the connective tissue may retain juvenile characteristics (Fig. 8-A). Cartilaginous ground substance, devoid of cells, may remain imprisoned in the dense connective tissue for a long time. These inclusions are progressively absorbed. In other areas subjected to compression—as by weight-bearing—the bone, devoid of cartilage, is covered by a thin layer of dense fibrous tissue which shows a tendency to assume the function of the cartilage (Fig. 8-B).

In addition to the appearance of collaginous fibrils in cartilage in polarized light.

FIG. 8-A

FIG. 8-B

Fig. 8-A: Shows last stage of degeneration. Cartilage almost completely destroyed and replaced by young scar tissue, containing inclusions of cartilaginous ground substance, deeply stained by hematoxylin.
Fig. 8-B: Complete replacement of cartilage by fibrous connective tissue.

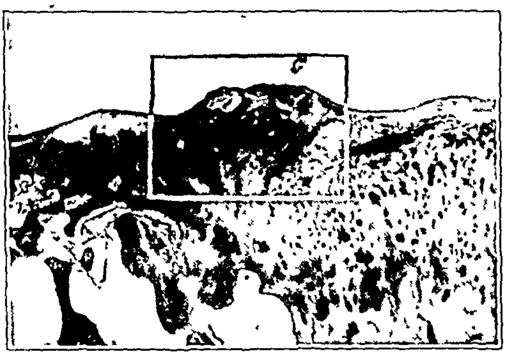

FIG. 9-A

Fig. 9-A: Formation of fibrin-containing microcysts in an organizing hemorrhagic area.
Fig. 9-B: High-power magnification of the area designated in Fig. 9-A.

FIG. 9-B

that of cartilage and bone cells was also studied, and comparison was made of normal and pathological tissues. This work was reported somewhat in detail in a preceding article[3]. The cellular elements in bone and cartilage, both normally and in cases of arthritis deformans of the hip joint, show properties of birefringence, localized exclusively to the nuclei. It is, however, necessary to examine the preparations at a higher magnification than that used for the photomicrographs shown here. The nuclear mass varies in appearance in the same preparation. Some nuclei show a neat "polarization cross"; others, on the contrary, are characterized by the presence of small bright blocks, separated by thin, dark diaphragms.

In preparations of the arthritic material, the optical properties of the remaining nuclei are not modified. In the majority of cases, however, the cell nuclei cannot be observed when the alterations of the collaginous fibrillar system are far advanced. In such cases the nuclei no longer appear, even when the plane of polarization is properly rotated.

Secondary Changes

The changes discussed occur in every case of arthritis deformans and are characteristic of it. Other, less frequent, alterations will now be described.

Breaks in the continuity of the osteocartilaginous line, which occur as one of the first conspicuous microscopic changes, may be followed by vascular penetration of the cartilage; this, in turn, gives rise to replacement of eroded and degenerative cartilage by fibrous connective tissue. In one of the cases studied (Fig. 9-A), a well-formed thrombus was

FIG. 10

FIG. 11-A

FIG. 11-B

Fig. 10: Shows advanced changes. The thickness of the cartilage layer varies, due to irregular erosion. There is progressive absorption of cartilage cells and partial transformation of hyaline into fibrocartilage. At the osteocartilaginous boundary there is an irregular microcyst, containing fibrino-hemorrhagic elements. The subchondral bone has become thickened.

Fig. 11-A: There is marked thinning of the articular cartilage, which has undergone replacement fibrosis. Note the island of cartilage which has become isolated by the interposition of bony trabeculae.

Fig. 11-B: Same specimen as in Fig. 11-A, prepared for study by polarized light. The birefringent collaginous fibrils have disappeared from the surface layer, which has become undermined by subchondral bone. The fibrillar system of the cartilage islands (*1* and *2*) is well demonstrated.

found, in a zone between dense connective tissue and degenerating cartilage. Evidence of the thrombotic origin of the changes shown in this portion of the section may be found in its triangular outline, with the base toward the surface and the apex toward the subchondral bony plate. With high-power magnification (Fig. 9-B) one can observe the structure of a thrombus. Numerous microcysts with vascular walls are shown, containing fibrin clots that are partially organized. The hemorrhagic zone is clearly bounded by cartilaginous tissue, on the right, and by fibrotic tissue, on the left. This has been observed frequently in other cases.

In polarized light, birefringency ceases abruptly where the cartilage ends, the thrombotic triangular area, with its fibrin-containing microcysts, being wholly dark because the birefringent collaginous fibrils have been destroyed and absorbed by scar tissue.

It is sometimes possible to overlook the point of origin of the thrombus during the stage of organization of the fibrin clot, as in the case illustrated in Figure 10, where a vessel has penetrated through a break in the osteocartilaginous boundary and subsequently ruptured, giving rise to hemorrhage. Most of the surrounding cartilage tissue undergoes degeneration, passing through an intermediate stage of fibrocartilage and finally undergoing replacement fibrosis.

Islands of cartilage are often found deep in the subchondral bone in regions where marked thinning of the articular cartilage has occurred (Fig. 11-A). These islands become

isolated through the development of surrounding trabeculae and, freed from compression, begin to grow, as shown by some cartilage cells which present evidence of early proliferation. The separation is often due to minute traumata.

In polarized light one can detect the characteristics of the original cartilage in these islands (Fig. 11-B). The parallelism of radial fibers of the deep layer of cartilage has been well preserved and is easily recognized. The plane of polarization which best demonstrates the birefringent characteristics of the cartilage is different from that necessary to exhibit the birefringent fibrillar system of the surrounding bone.

The description of other changes, such as marginal proliferations, fissures, other changes in the subchondral bone, Weichselbaum's formations, Pommer's cartilage nests, and other changes are omitted because they are well known and some of them are rare.

CONCLUSIONS

The fibrillar system constitutes the supporting framework of cartilage, the early weakening of which indicates loss of cartilaginous elasticity. Loss of elasticity is followed by erosion, marginal proliferations and, in the later stages, by invasion and replacement of cartilage by connective tissue. The degenerative process begins with the alteration of the fibrillar system of support. Degeneration increases with further alterations in the fibrillar system, and ends with the destruction of the joint surface.

A study of the reaction of the fibrillar system, therefore, becomes essential to an understanding of the changes characteristic of arthritis deformans. Further study of fibrillar systems would seem valuable in other pathological conditions. Such studies may be readily carried out by the use of polarized light; the technique is simple and interpretation of changes, otherwise difficult or impossible to recognize, is made possible.

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TENOSYNOVITIS OF THE EXTENSOR CARPI ULNARIS TENDON SHEATH *

BY DOUGLAS D. DICKSON, M.D., OAKLAND, CALIFORNIA, AND
CLARENCE A. LUCKEY, M.D., STOCKTON, CALIFORNIA

Non-suppurative tenosynovitis of the tendon sheaths of the extensor pollicis brevis and abductor pollicis longus is frequently observed. Familiarity with this clinical picture is due, in part at least, to the description of this entity by de Quervain [2, 3]. Inflammatory reactions are also found in other tendon sheaths of the hand, but not so frequently as in the above location. In 1938, Milch and Green reported a series of cases with calcification about the flexor carpi ulnaris tendon. Undoubtedly, numerous cases of tenosynovitis go unrecognized because of the somewhat bizarre clinical picture they present.

As far as we have been able to determine, tenosynovitis of the extensor carpi ulnaris tendon sheath has not been recorded previously in the literature. This condition produces a fairly consistent clinical picture: The patient usually has a twisting injury of the wrist, followed at a varying interval of time by pain, deep in the wrist joint. Subsequent to the injury, swelling may be noted about the distal end of the ulna. The pain may be aggravated by all wrist motions. Night pain may or may not be noted. Subjective sensory disturbances along the distribution of the dorsal cutaneous branch of the ulnar nerve may be present; they are described by the patient as "numbness" and "tingling". It cannot be stated with certainty whether or not these sensations are caused by a referred pain mechanism or by the surrounding of the dorsal branch of the ulnar nerve with oedematous soft tissue.

Examination reveals tenderness along the course of the extensor carpi ulnaris tendon and swelling about the distal end of the ulna. Close examination reveals grating within the extensor carpi ulnaris sheath on motion of that tendon. Repeated observations may be necessary to ascertain this fact. Various motions of the wrist joint will produce the pain; however, flexion and extension of the wrist, especially against resistance, as well as ulnar and radial deviation of the wrist against resistance, usually produce the pain; pronation and supination may also produce it. Localization of the pain, by the patient, deep in the wrist joint, should make the examiner check carefully for tenosynovitis of the extensor carpi ulnaris tendon sheath.

Oedema of the surrounding subcutaneous tissue has been present in all the cases seen. The dorsal branch of the ulnar nerve is situated in the oedematous tissue, and may account for the ulnar-nerve symptoms of which the patient complains. Section of the dorsal carpal ligament brings into view the fibrous sheath surrounding the extensor carpi ulnaris tendon. Section of this fibrous sheath reveals the markedly thickened synovial tissue with many small vessels visible throughout. The greatest reaction is noted where the tendon passes through the channel on the dorsum of the ulna, as well as distally near its insertion, where it is also situated in a snug fibrous-tissue tunnel. Immediately distal to the ulna, the fibrous sheath is quite thin to permit free wrist motion. In this area the tenosynovitis is minimal.

The diagnosis of tenosynovitis of the extensor carpi ulnaris sheath has been made on several occasions; however, in only six cases has there been operation and the diagnosis proved.

CASE REPORTS

CASE 1. On September 3, 1943, D. K., a white woman, fifty-two years old, bumped her right wrist while carrying a table. Immediate pain in the wrist followed. A plaster cast was worn for fifteen weeks without relief of pain. She was first seen by the authors on January 10, 1945. At that time she complained of pain in the region of the ulnar styloid process. The pain increased with wrist motion; night pain was present. Swell-

* Read at the meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 23, 1948.

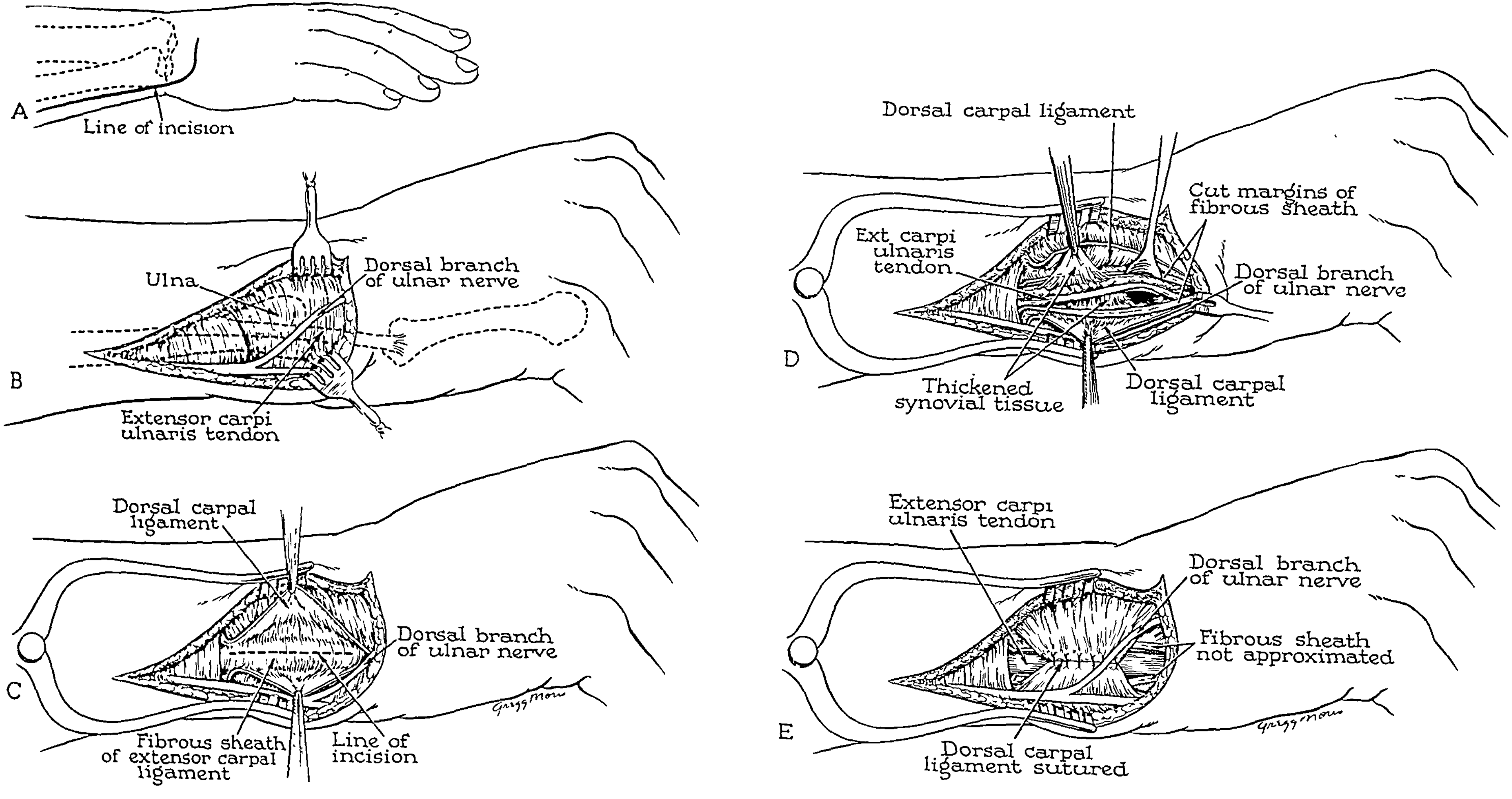

Fig. 1

A: Drawing shows the line of incision.
B: The relationship of the dorsal branch of the ulnar nerve to the extensor carpi ulnaris tendon is shown.
C: After sectioning of the dorsal carpal ligament, the fibrous sheath of the extensor carpi ulnaris is visualized.
D: After the fibrous sheath of the extensor carpi ulnaris has been sectioned, the thickened synovial tissue is seen.
E: The dorsal carpal ligament is sutured. The fibrous sheath of the extensor carpi ulnaris tendon is not approximated.

ing, increased local heat, and a "clicking" about the distal end of the ulna were also present. The true nature of the disturbance was not recognized at that time.

Shortly after our initial examination, the patient began complaining of pain and numbness on the dorsum of the ring finger and little finger. There was also some pain and tenderness over the lateral epicondyle of the humerus, at that time. A neurosurgeon, who saw the patient in consultation, made a diagnosis of scalenus anterior syndrome.

The patient continued to complain of severe pain at the distal end of the ulna upon motion of the wrist, and of numbness on the dorsum of the ring finger and little finger, in spite of rest and local applications of heat. Therefore, surgical exploration was done on April 7, 1946. Thickening of the fibrous tissue over the extensor carpi ulnaris tendon was noted, together with dislocation of this tendon, which produced a pull on the dorsal branch of the ulnar nerve. The tendon was stabilized, a portion of the dorsal carpal ligament being used to maintain the tendon in its normal sheath in its normal groove.

Following this procedure, symptoms were relieved for two weeks; then they gradually returned. The pain became quite severe, and did not respond to treatment.

On June 3, 1946, the area was again explored. The fibrous sheath of the extensor carpi ulnaris tendon was opened widely. Considerable reaction was found in the synovial tissue, which had the appearance of granulation tissue. Immediate and permanent relief of pain followed this procedure. Pathological study of the tissue revealed non-specific tenosynovitis. After this second operative procedure, the patient was considerably relieved of symptoms.

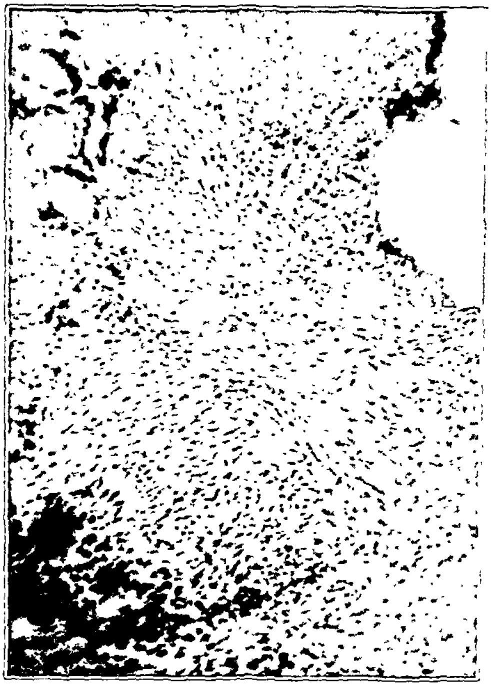

FIG. 2

Case 3. Photomicrograph of synovial tissue after excision. Note the marked thickening of the tissue.

CASE 2. In 1944, E. U., a thirty-year-old white male, was cranking a trailer. The crank flew off and twisted his wrist. Pain in the right wrist and swelling around the distal end of the ulna followed. He complained of pain, radiating into the region of the fifth metacarpal. This pain persisted, in spite of immobilization by strapping, and was always aggravated by activity. Examination revealed swelling about the distal end of the ulna; pressure in this region produced paraesthesia on the dorsum of the ulnar side of the hand, which did not extend into the fingers. The patient had a good deal of pain with the forearm in pronation; and there was moderate grating in the tendon sheath of the extensor carpi ulnaris when the wrist was deviated radialward and then ulnarward.

In view of the severity of the pain in the region of the extensor carpi ulnaris tendon, surgical intervention was decided upon. Surgical incision on April 15, 1946, revealed a rather marked thickening of the tendon sheath, together with a considerable amount of new blood-vessel formation, after the fibrous sheath had been opened. The fibrous sheath was not resutured. After incision of the fibrous sheath of the extensor carpi ulnaris tendon and excision of the thickened synovial tissue, symptoms were completely relieved.

CASE 3. J. S., a white male, aged fifty-six years, stated that on February 5, 1947, while he was prying a board through a tub of ink, he twisted his right wrist. Immediately, he experienced considerable pain in the wrist and swelling on the dorsum of the hand. The pain was quite severe and was aggravated by activity. In addition, he complained of numbness on the dorsum of the ring and little fingers. He stated that immobilization of the wrist resulted in relief of pain.

Physical examination revealed a mild amount of swelling on the dorsum of the hand toward the ulnar side. When the wrist was forced ulnarward, there was pain in the region of the extensor carpi ulnaris tendon. There was a moderate amount of tenderness around the ulnar styloid process, and over the tendon of the extensor carpi ulnaris, with pain in this region on flexion and extension of the wrist against resistance. The patient complained of some pain on compression and on retraction of the wrist. A plaster cast was applied for three weeks with relief of pain; this recurred, however, after the cast had been removed.

On April 17, 1947, the fibrous sheath of the extensor carpi ulnaris tendon was incised. Extensive thickening and small blood-vessel proliferation of the synovial lining were encountered. The hypertrophied tissue was excised. The fibrous sheath was not resutured. There was immediate relief of symptoms following this procedure, with complete relief in eight weeks.

CASE 4. C. H., a white male, aged thirty-four years, stated that in January 1947, he twisted his right wrist while lifting a chain onto a hoist. Rather acute pain followed. The pain persisted and, three weeks following his injury, strapping of the wrist was recommended by his doctor. The strapping produced some relief, but the symptoms returned after the straps had been removed.

The patient was first seen by the authors in April 1947, at which time examination revealed definite swelling over the distal end of the ulna, and moderate tenderness along the course of the extensor carpi ulnaris tendon sheath. Definite grating was demonstrable in the extensor carpi ulnaris tendon sheath on radial and ulnar deviation of the wrist. He also complained of weakness of grip and of paraesthesia along the ulnar side of the dorsum of the ring finger on the right hand.

Since immobilization did not relieve his symptoms, surgical exploration was done on April 24, 1947. The fibrous sheath of the extensor carpi ulnaris was incised. Extensive thickening of the synovial lining, together with a marked hemorrhagic injection of this tissue, was encountered. The reaction was most marked directly over the distal end of the ulna and distally near the insertion of the tendon. (At these two sites, the tendon passes through the smallest and the most confined portion of its channel.) The fibrous sheath was not resutured. Complete relief followed this procedure.

CASE 5. E. H., a white woman, aged twenty-three years, sustained a Colles's fracture in 1945. Intermittently since then, she had had pain in the region of the left extensor carpi ulnaris tendon, associated with increased activity of the wrist. When the authors first observed her in May 1947, she was unable to continue with her work as a typist because of the severity of the pain. Examination revealed swelling and tenderness along the course of the extensor carpi ulnaris, and pain in this area on wrist motion, especially with radial and ulnar deviation of the wrist.

A plaster cast was worn for three weeks with relief of pain; however, upon resumption of activity, the pain recurred. Therefore, the tendon sheath was incised surgically. A moderate amount of thickening and hyperaemia of the synovial tissue were noted. The fibrous sheath of the tendon was not closed. Immediate and permanent relief of symptoms resulted.

CASE 6. E. S., a white woman, aged twenty-five years, in 1944 was working in a Naval Air Station as a mechanic's helper, using a screw driver constantly. At this time she noted considerable pain in the region of the ulnar styloid process. A few weeks later she noted a cystic swelling on the dorsum of her wrist, just distal to the ulnar styloid process. A diagnosis of a ganglion was made, followed by surgical excision of the mass in 1945. The mass recurred in 1946, and during the following year it gradually became larger and more painful, with considerable night pain and crepitation.

Examination revealed a cystic type of swelling, about two centimeters in diameter, on the dorsum of the wrist, just distal to the styloid process along the course of the extensor carpi ulnaris tendon. Extensive crepitation and marked tenderness along the course of the extensor carpi ulnaris tendon were demonstrated.

On December 15, 1947, the bulbous mass was exposed surgically, and was found to consist of granulation tissue. The sheath about the extensor carpi ulnaris tendon was distended with granulation tissue. Pannus formation was noted about the tendon. Degeneration of a portion of the extensor carpi ulnaris tendon was characterized by a gelatinous type of necrosis. After a thorough débridement, the wound was closed. Bacteriological studies failed to demonstrate any growth of organisms. Microscopic examination of the material which had been removed showed granulation tissue. The patient made a prompt recovery with relief of all symptoms.

DISCUSSION

The clinical picture produced by tenosynovitis of the extensor carpi ulnaris tendon sheath has been presented. In some instances the pain may be localized by the patient as deep in the wrist joint and the true diagnosis of tenosynovitis of the extensor carpi ulnaris tendon sheath may be overlooked. Undoubtedly, many of these cases have been diagnosed incorrectly in the past. We feel certain that the diagnosis of injury to the triangular ligament of the wrist joint has been made in many instances, when the true nature was a tenosynovitis of the extensor carpi ulnaris tendon sheath. Residual pain following Colles's fracture, in some instances at least, is due to a tenosynovitis of the extensor carpi ulnaris tendon; if looked for, it may be found more frequently than it has been in the past.

Hemorrhage, which probably takes place in the sheath at the time of injury, produces a non-specific inflammatory reaction in the synovial tissue. The long and markedly confined fibrous sheath, through which the extensor carpi ulnaris tendon glides, undoubtedly is a most important factor in producing the tenosynovitis, and also in keeping the condition active.

While most of the thickened synovial tissue was removed in the greater number of our cases, merely opening the fibrous tunnel throughout its entire length would probably relieve symptoms.

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DISCUSSION

REFLEX SYMPATHETIC DYSTROPHY

(Continued from page 894)

Judovich injected an aqueous solution of pitcher plant, observing that it influenced sensory fibers without affecting the motor fibers, and relieved neuralgic pain without causing changes in the skin sensation.

Further investigation by Stewart, Judovich, Hughes, and Walti[1,2], on the physiology and chemistry of this problem, showed that the active principle of the solution of pitcher plant was identical in its action to that of a solution of ammonium sulphate. This pitcher-plant solution was finally brought to the medical profession in ampoules, under the trade names of "dolamin", "sarapin", and possibly others. We have found considerable satisfaction in the use of dolamin in paravertebral and paraneural injections for the relief of causalgia and neuralgia; it has a more prolonged effect than procaine, and seems to have a definite influence on the favorable progress of these conditions. This has been particularly true in those cases of nerve injury or in neuralgia following the removal of intervertebral discs.

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DR. HAROLD R. BOHLMAN, BALTIMORE, MARYLAND: Dr. Toumey has given us an excellent presentation. The occurrence, in our experience, has been greater in females than in males; fortunately, minor cases have been encountered much more frequently than the more severe types of cases. The entire syndrome, at times, borders on the field of psychosomatic medicine. Often, causalgia occurs with most severity in those cases with marked neurocirculatory aesthenia. I think that Dr. Toumey's grouping of the terminology is a help in classifying the cases.

With regard to causation, pressure is one of the most serious factors, whether it is external pressure due to dressings or casts, or internal pressure produced from swelling within. We have also been impressed with the frequent occurrence of this condition in patients treated by diathermy, particularly with the short-wave machine. The current, surging through the tissues, causes burns, with higher temperatures when it goes through the more dense tissues. The injured extremity should be fixed properly and the adjacent parts should be mobilized. Early activity of the swollen extremity is essential. Treatment should be early,—first, by procaine injections, and then by sympathectomy, as Dr. Toumey has emphasized so clearly.

DR. JAMES W. TOUMEY (closing): I want to thank both discussors. I noted that both of them emphasized the point that, when dystrophy develops, it should be treated without delay,—that is, the results of sympathectomy are better if the operation is done early. I want to emphasize that again.

In conclusion, I have no quarrel with the neurosurgeon's use of the term "causalgia", as a result of nerve injuries; but I do think that "reflex sympathetic dystrophy" is a good term for this large group of cases, characterized by abnormal sympathetic phenomena, which occur either with or without primary traumata.

SYNOVECTOMY OF THE KNEE JOINT

A Review of the Literature and Presentation of Cases

BY MYRON L. PARDEE, M.D., CLEVELAND, OHIO

From the Division of Orthopaedic Surgery, University Hospitals, Cleveland

Synovectomy of the knee joint has been in general use as a surgical procedure for nearly a quarter of a century. Although first described by Mignon in 1900, it did not gain recognition until 1923, when Swett reported the results of, and indications for, synovectomy in cases of chronic infectious arthritis. While the end results of a series of forty patients subjected to synovectomy at this institution during the last twenty years were being reviewed, it was thought that an evaluation of the indications for operation and of the long-term end results might be of interest in estimating the value of this procedure.

A number of pathological conditions involving the synovial membrane of the knee joint are benefited by synovectomy. Those most frequently encountered are:

1. Chronic infectious (atrophic) arthritis.
2. Traumatic arthritis.
3. Hypertrophic arthritis.
4. Osteochondromatosis.
5. Benign tumors.
6. Intermittent hydrarthrosis.
7. Villous arthritis. This diagnosis is used by the author to designate those cases in which no definite evidence of atrophic or hypertrophic arthritis is noted, and a history of trauma is vague or not present. Such a patient presents a swollen, tender knee, with a thickened synovial membrane which shows villous formation at operation. Roentgenographic evidence of arthritis is not noted. Clinically, these patients have signs and symptoms of arthritis, but the disease cannot be classified precisely as traumatic, atrophic, or hypertrophic arthritis.
8. Pigmented villonodular synovitis. As reported by Jaffe, Lichtenstein, and Sutro, in 1941, this ~~disease is not easy~~ of diagnosis before biopsy or arthrotomy of the knee has been done. Aspiration of serosanguineous fluid, followed by repeated effusions, should make one suspicious of this entity. Details as to diagnosis may be found in the original article of Jaffe and his associates. Synovectomy must be thorough, or the condition may recur. Roentgenotherapy is reported to be superior to synovectomy, and is probably the treatment of choice after the diagnosis has been established.

Tuberculous synovitis, even without any evidence of bone involvement, does not respond favorably to synovectomy. Persistent pain, recurrent effusion, and some degree of fibrous ankylosis are the usual sequelae following synovectomy for tuberculosis, with arthrodesis being resorted to in a large proportion of cases.

By far the greatest number of the reports on synovectomy found in the literature are concerned with the results of the operation in cases of chronic infectious and hypertrophic arthritis of either the mono-articular or polyarticular type. In his first communication, in 1923, Swett stated that "the operation is most likely to succeed if it is done in the type of case or at the stage of the disease where the damage is entirely synovial, the effusion extensive, and the cartilages are not ulcerated". A nearly directly opposite opinion was enunciated by Speed, when he said that "synovectomy should be limited to those joints in which the synovial membrane alone or in combination with the cartilages has been irreparably damaged, and, after the active process has subsided, prolongs the disability. It is a question more of mechanics than of removal of infection."

Heyman, presenting an excellent discussion of the anatomical considerations involved, stated that the object of synovectomy was (a) to relieve pain, and (b) to restore the maximum degree of function. He also stressed the importance of the careful selection of cases. This point was likewise brought out by David, in commenting on the general constitutional condition of the patient, and by Magnusson, who thought that the mental attitude of each individual patient was a prime factor in the consideration of synovectomy.

In commenting on synovectomy in cases of chronic arthritis, Allison and Coonse state that the age, general physical condition, and hopeless inactivity of the patient are not contra-indications to operation. They believe that removal of both menisci in a complete synovectomy improves function and gives greater relief from pain. In cases of multiple proliferative arthritis, these writers and Bernstein agree that striking results are noted after synovectomy, with all of the involved joints less swollen and painful. Bernstein also concludes that synovectomy in patients with mono-articular osteo-arthritis, or atrophic arthritis without erosion of the articular cartilage, gives the best results, and that improvement in the knee continues with its use after operation. Carruthers is of the opinion that: "Synovectomy should be the treatment of choice in the majority of cases of chronic synovitis, chronic arthritis, and even in the far-advanced cases of chronic hypertrophic villous arthritis involving the average knee". He stresses the fact that age is not a contra-indication to operation in these conditions.

Painter, writing in 1932, presented a clear picture of the synovial changes that take place in chronic infectious arthritis. He believed that "the value of synovectomy to the patient was the removal of that which had accumulated within the articulations as a result of cellular reaction to toxic invasion and, though at the time innocuous, was putting the joints at a mechanical disadvantage, too long a continuance of which might have resulted in permanent disability". This is essentially the same opinion that was elaborated previously by Speed, but it does not appear to be shared by many other men.

In 1938, Swett stated that the consensus during the time since publication of his original paper pointed to the fact that "synovectomy may well be employed in a joint in which extensive induration and fibrosis of the capsule, enlargement of the synovial villi, and persistent increase of joint fluid are present". In a subsequent communication, a year later, his opinion was that the proper selection of cases is based upon the nature of the predominant type of the local process, and upon the stage of that process. Those processes that are primarily and predominantly synovial in origin and extent are favorable. Those local inflammatory conditions that primarily and predominantly involve the bone ends, the articular cartilage, the joint capsule, and the muscles are unfavorable.

Pfeiffer and Bach point out that synovectomy, combined with posterior capsuloplasty, gives the best results in cases of chronic rheumatoid arthritis where flexion contractures have developed.

Krida, and Porter and Lonergan, in presenting reports of cases of intermittent hydrarthrosis, agree that synovectomy is the treatment of choice in this condition.

Traumatic arthritis of the knee and concomitant synovial changes respond more favorably than other types of disease to synovectomy. This is the opinion of Boon-Itt and of Ghormley and Cameron, and is borne out in the findings of the author's group of cases. Ghormley and Cameron also state that synovectomy is useful in synovial osteochondromatosis and in xanthoma, or other benign tumors. They believe it of less value, although indicated, in some cases of chronic infectious arthritis: they likewise consider it applicable in chronic synovitis, but point out that the prognosis must be guarded. They do not think that routine removal of the meniscus is indicated, unless it is damaged or is causing damage to the articular cartilage of the joint.

Experimental Findings

Before attempting to correlate these reports on the types of diseases amenable to

synovectomy and their indications, it may be well to review briefly the experimental work that has been done on this subject. Key, in 1925, did the first work on the reaction of the synovial membrane following synovectomy. He found that, following hemisynovectomy in rabbits, the synovial membrane is reformed in an approximately normal fashion some sixty days after operation. Key states: "The new synovial membrane is formed *in situ* by metaplasia of underlying connective tissue cells and there is little or no tendency for surface growth from the edges to cover the denuded area. . . . The synovial cells are connective tissue cells slightly specialized by their location on a free connective tissue surface." One point mentioned by Key which seemingly has escaped general notice is that, in about one quarter of the joints he operated upon, one or more osteocartilaginous processes were formed on the femur postoperatively. These were not formed as spurs at the cartilage margins, but were usually well down on the side of the condyle, and were seen earliest in the section of a joint four days after operation.

Wolcott, in performing synovectomy on dogs, found essentially the same gross and histological changes that Key reported. Efskind, in 1941, in an extensive review of synovial regeneration following synovectomy on dogs, stated that the outcome of this regeneration is a synovial membrane which shows only slight anatomical differences from the original, while the subsynovial tissue presents a considerable degree of fibrosis and scarcity of blood vessels. He also noted that total synovectomy is followed by a protracted decrease of the absorptive power of the synovial tissue; this remains demonstrable for fifteen days, although decreasing in intensity. This may be the explanation for the occasional clinical case which has persistent effusion after operation, although the greater part of the synovial membrane with ability to secrete has been removed.

Hosford reports that an arthrogram, done on a patient six years after synovectomy for multiple synovial chondromata, revealed the synovial cavity to be of normal appearance, shape, and size, with a smooth and even outline.

Indications

With this experimental evidence at hand, we now may attempt to correlate and evaluate the various opinions expressed as to the type of case and the indications for synovectomy. In general, aside from tuberculous synovitis, the consensus is that the following conditions benefit from synovectomy in the order listed: (1) benign tumors of the synovial membrane, (2) osteochondromatosis, (3) traumatic synovitis, (4) the mono-articular type of chronic atrophic arthritis, and (5) the mono-articular type of hypertrophic arthritis. It must be assumed, of course, that the last two diseases mentioned are in a quiescent state, and that the usual conservative therapy has been employed without beneficial result.

As regards the indications for synovectomy, it is of interest to review the theoretical considerations enumerated by Swett in his original article, and to determine how they have been borne out since that time. They are summarized as follows:

1. That manual removal of the inflammatory exudate might promote resumption of joint function.

2. That the organized synovial exudate contained micro-organisms which were capable of continuing the activity of the process within the joint.

3. That the arthritides show fairly constant suboxidation processes, and that persistence of this abnormal metabolic state apparently prolongs the arthritis. Manual removal of the diseased synovial tissue may hasten restoration of function.

In a consideration of the indications for synovectomy, it is difficult to make one statement which will express the opinion of the majority of authors quoted. Divergence of opinion is proof *per se* that the indications for synovectomy are not clear-cut. When all the variables are taken into consideration, it becomes apparent that pain is probably the paramount indication, regardless of the etiology of the disease process. Effusion and loss

TABLE I

Preoperative Diagnosis	Number of Cases
Villous arthritis	20
Hypertrophic arthritis	5
Atrophic arthritis	5
Traumatic arthritis	4
Tuberculosis	2
Osteochondromatosis	2
Xanthoma	1
Synovioma	1
Total	40

of motion may be well tolerated, but pain necessitates relief by some means. Synovectomy offers the patient the best chance of relief from pain in the knee, due to any one of the causes mentioned previously.

Report of Cases

In this series of forty patients operated upon from 1927 to 1947, eight had bilateral synovectomy. Without exception, all of these patients requested that the second operation be done because of the relief obtained from the first synovectomy. Twenty-two females and eighteen males comprise the group, with ages ranging from ten to over sixty years; the greatest number fall in the fourth decade. Nineteen patients gave a history of trauma. Sixteen patients had had symptoms for over five years; pain, swelling, and stiffness of the knee were present in 55 per cent. of the entire group. Of the total number of patients operated upon, only three did not complain of pain in the knee. A normal range of motion before operation was noted in eleven cases. The preoperative diagnosis and the number of cases are shown in Table I.

Conservative therapy, including rest, weight reduction, immobilization in plaster, physiotherapy, and other usual measures, had been used in twenty-four of the patients without any lasting success.

OPERATION

The operative technique of synovectomy was essentially the same in all cases. A tourniquet was used in each case. With the exception of the first few cases, in which a split patellar incision was used, the knee joint was approached through a medial parapatellar incision. After the joint capsule had been opened, a thorough inspection of the joint was made. The entire synovial membrane, with the exception of that portion lining the posterior compartment of the knee joint, was removed in all cases. Osteocartilaginous spurs at the articular margins of the femur and tibia were removed when their size or position was such that they provided a focus of irritation or interfered with joint function. Spur formation of the patella was treated accordingly, and degenerated cartilage of its articular surface was trimmed out. Patellectomy has been done in only two of the most recent cases, where gross degeneration of the articular surface of the patella was noted. Sufficient time has not elapsed to permit evaluation of the efficacy of this procedure; but in the short period of follow-up, no untoward effect has been observed. The menisci were removed only when gross pathological changes were demonstrable. Meniscectomy has not altered the postoperative course in any discernable manner.

Postoperative Course

The postoperative care did not differ from that described by other authors. In general, the patients were allowed to be up on crutches in ten to fourteen days, with gradual

weight-bearing at the end of three weeks. The postoperative course was governed by the patient's response, as evidenced by the appearance of joint effusion, pain, or reduction of motion.

No complications were encountered in this series. Fifteen patients had manipulations, at periods varying from three weeks to three months, when decreased motion indicated the presence of adhesions. It ought to be stressed that manipulation must be gentle, and that restoration of a full range of motion is not desirable if force must be used. Three patients were subjected to arthrodesis, two because of tuberculosis, and one because of persistent pain, swelling, and loss of motion.

Pathological Diagnosis

Microscopic examinations were done on thirty-nine specimens removed at operation. Thirty-four were reported as chronic synovitis, two as tuberculosis, one as xanthoma, and two as synovioma.

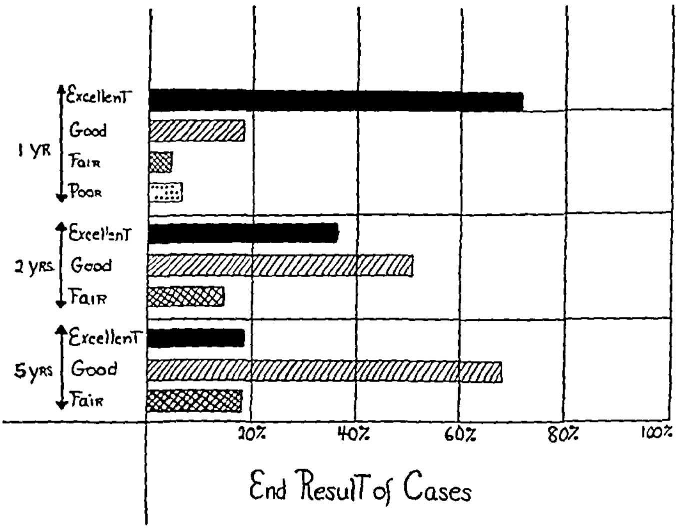

CHART I
End results, one to five years after synovectomy.

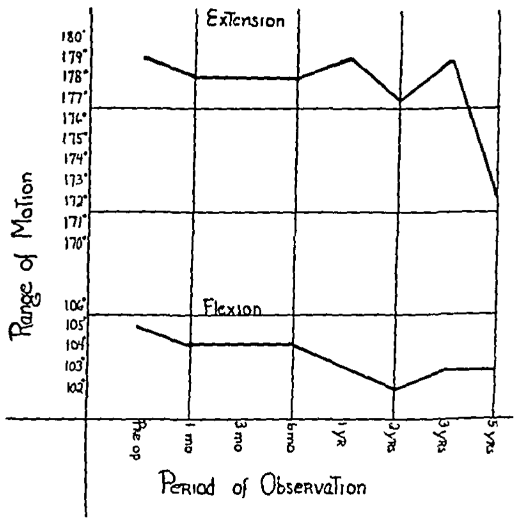

CHART II
Range of motion in flexion and extension.

End Results

The end results of synovectomy were classified as "excellent", "good", or "fair". The result was considered excellent when no pain, swelling, or stiffness was present, and a range of motion of full extension and 90 degrees or more of flexion was possible. Occasional pain and swelling, with no reduction of the range of motion present before operation, constituted a good result. A fair result was considered to be that in which pain and occasional swelling were noted without reduction in motion, but the patient stated that the operation was beneficial.

A graphic representation of the end results (Chart I) shows clearly that the immediate results are misleading. One may expect, however, that the eventual result will be satisfactory in a sufficient number of cases to make the procedure worth while. Three patients had arthrodeses, as stated previously. Eight patients could not be traced for more than one to three months after operation. It is a logical assumption that the majority of these patients had successful results, or they would have returned to their private physicians for further therapy.

The range of motion is depicted in Chart II. This represents the average degree of flexion and extension. It is of interest that no significant decrease in motion occurs until five years after operation, and then only in extension.

Approximately one quarter of the total number of patients operated upon have been followed for five to eighteen years after operation. Even though they all experience some

degree of pain, intermittent swelling, and impairment of motion to a variable degree, they all state that the operation was of decided benefit. Relief from pain was stated to be the most common benefit of synovectomy.

DISCUSSION

So many variable factors are encountered that it is extremely difficult to arrive at a precise and critical evaluation of the indications for synovectomy, or of the end results. Pain, an entirely subjective phenomenon, is what usually brings the patient to the physician, and relief from pain is the criterion most commonly accepted by the patient as the expression of the success of the operation.

Speaking in general terms, of necessity, we believe that synovectomy is justified under the following conditions:

1. A patient presents a painful, swollen knee, resulting from any one of the causes listed previously, on which conservative measures have been tried for an adequate period (three to six months) without avail. Tuberculosis is a contra-indication to synovectomy.
2. The general physical condition of the patient before operation must be as good as possible. Age is not an important factor.
3. Intelligent cooperation of the patient as regards postoperative care must have been assured before synovectomy is done.

It was noted during the examination of these patients postoperatively that, as symptoms of pain and swelling appeared, so also did crepitation, synovial thickening, and roentgenographic evidence of spur formation. These findings are in direct proportion to the symptomatology in most cases, but never are so prominent as prior to operation.

Seemingly this is presumptive support of what Key noted experimentally, especially the new spur formation. Evidently the connective-tissue cells, after undergoing metaplasia and forming synovial tissue, are subject to the same insults and respond in the same manner as the original synovial membrane, but to a lesser degree. Ghormley and Cameron cite one case in which a second operation was done. Synovial thickening and other changes similar to those seen at the first synovectomy were noted. It is reasonable to suppose that the osteocartilaginous proliferative changes found by Key take place in a certain number of patients after synovectomy. This, coupled with the finding of Ghormley and Cameron, appears to be a logical explanation for the failures or poor results that are seen, even when comparable cases have excellent results.

The end results of synovectomy, in terms of relief from pain and increase of function, are universally good in cases of traumatic arthritis, chondromatosis, and benign tumors of the knee joint. An average of 60 per cent. improvement in cases of the mono-articular type is obtained in chronic proliferative arthritis and hypertrophic arthritis. Patients with the polyarticular type of rheumatoid or hypertrophic arthritis can be expected to have the poorest results.

When synovectomy is done for benign tumors or for osteochondromatosis, there is every reason to expect that the regenerated synovial membrane will present a normal anatomical and histological appearance. When the same operation is done for some other cause, as for chronic synovitis, one may expect the synovial response to be in proportion to the degree that the predisposing pathological process is still present. This response will be slower in appearance, and of less intensity, but is a definite certainty.

The end results depend upon two main factors, first, cooperation of the patient in restoration of function to the knee after operation, and, second, the pathological process which necessitated synovectomy. Regardless of etiology (excluding tuberculosis), one may expect 75 to 85 per cent. of satisfactory results one year after operation, provided that cooperation has been secured. Another 10 to 20 per cent. of patients will probably be benefited by the operation, but one cannot term the result completely satisfactory. Poor results may be expected in 5 per cent.

As the number of years following synovectomy increase, it is our experience that the number of excellent results decrease. However, a satisfactory end result may be predicted in 60 to 70 per cent. of cases, provided the original etiological agent remains static or decreases.

In reviewing Swett's theoretical considerations at the present time, one may state that the first and third conclusions probably are correct in general. No definite evidence has been presented which substantiates the premise that organized synovial exudate contains micro-organisms which are capable of continuing the activity of the process in the joint. Manual removal of the diseased synovial tissue does alter the symptomatology, but does not prevent a return of the condition at some later date.

NOTE: The author wishes to express his appreciation to Dr. M. Harbin, Dr. C. Heyman, and Dr. J. Murphy for their advice in the preparation of this article.

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ESTROGENS AND BONE FORMATION IN THE HUMAN FEMALE*†

BY MARY S. SHERMAN, M.D., CHICAGO, ILLINOIS

From the Department of Surgery, Division of Orthopaedic Surgery, University of Chicago

In 1926, Riddle and Reinhart first observed that the blood-calcium values of female pigeons fluctuate widely. They showed that a rise in these values begins before ovulation and reaches a peak, as much as four times the normal level, some fifteen hours before the egg reaches the shell gland. During the succeeding three or four days, the blood calcium falls to normal and remains there until the next ovulatory cycle is to begin. Later, this same pattern was found in hens by Hughes, Titus, and Smits, and it has since been noted in several other species of birds [7, 29, 35].

These observations led to an attempt to explain how the organism can tolerate such extreme variations in blood-calcium content, and why the phosphorus level remains unchanged. In 1933, Benjamin and Hess provided the answer by proving that the hypercalcaemia is due entirely to an increase in the non-filtrable, non-ionized, protein-bound fractions, while the ionized fraction remains unchanged. Thus the bird is provided with an "extra-metabolic" method for handling rapidly the large amounts of calcium necessary for egg-laying. A similar mechanism has been observed in the cod, the puffer [24], and the toad Xenopus, all of which lay eggs without shells but with a high calcium content [43]. In viviparous fish, however, serum-calcium values are identical in the male and female and do not vary. In mammals, no such variations in blood chemistry have been found.

The workers of several laboratories have since confirmed these observations, and have shown that the same effects can be produced in both male and female birds by the injection of estrogenic compounds [4, 35, 37, 38, 39, 41]. That the production of hypercalcaemia is not a function of the parathyroid glands has been shown by Avery, Scott, and Conrad, who were unable to produce significant rises in the serum calcium of hens, pullets, or cockerels by the injection of parathyroid hormone [5]; and by Riddle, Rauch, and Smith, who produced the characteristic effects with estrogens injected into parathyroidectomized pigeons. The serum-calcium rise in response to estrogens will also take place in castrate, hypophysectomized, and thyroidectomized animals [38, 53].

In 1934, Kyes and Potter observed that hyperossification in the marrow cavities of the bones of female pigeons occurs before ovulation and recedes after it. When it was realized that the changes of blood calcium, the intramedullary ossification, and the reproductive cycle were correlated in the bird, many experiments on the relationship of estrogens to bone formation followed. It was shown that ossification within the marrow cavities of pigeons [8, 9, 10], ducks [7, 29], and the domestic sparrow [35] can be produced by the injection of natural or synthetic estrogens. These changes can be obtained in males as well as in females, and they all subside with the withdrawal of the estrogen. They are accompanied by the usual rise in blood-serum calcium and also by a rise in serum cholesterol and lipids.

Similar, but much less spectacular, changes can be induced in the bones of several small mammals, even though they exhibit no changes in blood-calcium levels. Workers are generally in agreement that an increase of bone can always be produced in the bones of rats and mice by the injection of sufficient estrogen, that this bone is absorbed without leaving any trace when the estrogen is withdrawn, and that the amount of change decreases with increasing age of the animal [16, 17, 18, 20, 21, 27, 43, 47, 48, 50]. The bone changes can

* Read at the Annual Meeting of The American Orthopaedic Association, Quebec, Canada, June 4, 1948.
† This work was aided by grants from the Douglas Smith Foundation and the Otho S. A. Sprague Memorial Institute.

FIG. 1-A

Roentgenogram of the skull, six months after onset of initial symptoms. There is generalized osteoporosis, fuzzy thickening, and irregular areas of increased density. The appearance is that of Paget's disease.

be obtained in the absence of hypophysis and parathyroids, and also in animals on a diet deficient in vitamin D [40, 42].

These observations on experimental animals naturally raised the question as to whether such an effect could be utilized clinically. The obvious difficulties involved in definitive evaluation of human material have limited the contributions in this field to a few careful metabolic studies and sundry miscellaneous observations.

It has long been known that estrogens are in some fashion concerned with the rate of growth and maturation of the skeleton of the human female. Two groups of workers have reported on the syndrome which occurs in patients with primary ovarian insufficiency [3, 53]. In these patients, growth of the bones is altered so that adult stature is decreased. Furthermore, the bone age is retarded and the epiphyseal plates close late.

Although Johnston claims to have produced a decrease in calcium retention by the administration of estrogens to adolescent girls, his results are at variance with those of other workers in the field. Albright and his associates studied postmenopausal osteoporosis as a hormonal deficiency, and found that they could produce and maintain calcium retention in the human being by the injection of estrogens. In subsequent careful and detailed studies, the same group confirmed and extended their earlier observations [36]. These metabolic effects were accompanied by a satisfactory improvement in symptoms. The interpretation offered by Albright is that osteoporosis is a disorder in which the etiological factor is a hypofunction of the osteoblasts in producing bone matrix. In some fashion, not yet clearly understood, estrogens are assumed to stimulate the osteoblasts, so that the process of ossification can proceed normally. These workers admit, however, that irrefutable evidence that the bones have actually become more dense has never been obtained by them or by others. It is the purpose of this paper to present such a case.

M. T., a white housewife, was born in Belgium, but had lived in Illinois since the age of twelve. The only significant part of her past history related to her pregnancies. The first of these, when she was thirty-four, was uneventful. There followed two miscarriages and another successful delivery. She then had a third miscarriage. When she was thirty-seven, her sixth pregnancy resulted in a stillbirth and, for reasons which cannot be ascertained, she was subjected to a panhysterectomy.

The patient was then perfectly well until she was fifty-four years old. At that time, bowing of the right tibia began. Six months later, in June 1942, the patient fell (while jumping rope!) and injured her left knee. Roentgenograms revealed no fracture, but led to the diagnosis of Paget's disease. She had no great difficulty for a while except that her teeth, which had previously been good, "seemed to melt away" and were all extracted. Roentgenograms made before the extraction showed a well-preserved lamina dura (alveolar bone), a finding which Albright believes to exclude hyperparathyroidism.

In September 1942, the patient fell from a chair and injured her left leg. After being in bed for a few days, she got up on crutches. Two weeks later, she fell and sustained a fracture of the lower portion of the right femur. After this she was bedridden, both because of the fracture which did not heal, and because of bone pain which became progressively more severe. During this period, she had dizzy spells which gradually disappeared. She also began to lose her hearing.

FIG. 1-B

Roentgenogram of pelvis and upper portions of femora, taken at the same time, shows marked rarefaction of all bones, and irregular trabeculation and thickening of the pelvis and right femur The left femur shows only reduced density. The cartilage space of the hips is of normal width.

Six months after the first injury (in January 1943), the patient entered a hospital, roentgenograms were taken and revealed changes in many bones (Figs. 1-A and 1-B). The skull showed marked thickening and fuzziness with many areas of increased and of decreased density. The pelvis, both femora, and the right tibia had a similar appearance. The right humerus appeared thickened and bowed, with prominent trabeculation. All involved bones were markedly osteoporotic, a finding which was emphasized by the contrasting density of the other bones. There was no evidence of any disorder of the joints.

Routine blood and urine examinations were normal. Two determinations of serum calcium were made:

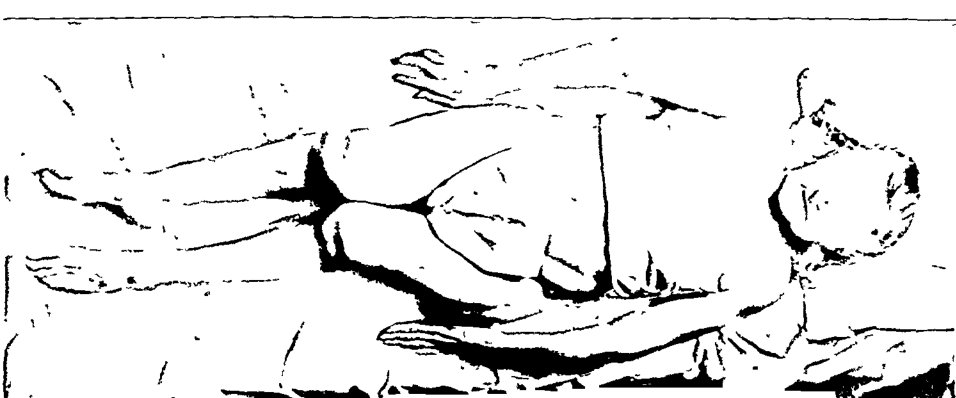

FIG. 2

Note deformity of right arm and extreme bowing of both thighs. The skull appears normal

FIG. 3

Roentgenogram, three years after onset of symptoms, shows increased osteoporosis with collapse of the third, fourth, and fifth lumbar vertebrae. The laminae and spine of the first sacral vertebra have retained their density.

one was recorded as 13.4 milligrams per 100 cubic centimeters, and the other as 12 milligrams. The single determination of serum phosphorus was 6.2 milligrams per 100 cubic centimeters. A diagnosis of hyperparathyroidism was made and an operation was performed. The thyroid was described as small and normal in appearance. Four normal-appearing parathyroids were found, and one was removed from each side. Following the operation, the patient's serum calcium ranged between 9.2 and 9.8 and her phosphorus between 3.2 and 4.8 milligrams per 100 cubic centimeters. There was no improvement in symptomatology, and the roentgenographic changes continued to progress.

From the description of the histological preparations, it is difficult to understand why the diagnosis of parathyroid adenoma was made. Unfortunately, neither sections nor gross material are available for re-evaluation.

For a few months the patient had rather indifferent therapy with small amounts of vitamins and minerals; she was finally discharged in the eighteenth month of her disease.

For the next two years, she remained at home, bedridden and growing gradually worse. She sustained numerous fractures with a minimal amount of trauma. The bone pain, which at first was present only with activity, became more severe, so that she could not be touched. Finally, severe cramps and muscle twitchings

appeared. In January 1946, three and one-half years after the initial injury, the patient was first admitted to the University of Chicago Clinics.

The patient was a well-nourished white female of fifty-eight years, who had multiple gross deformities. Most noticeable were the thickened and bowed right humerus, the shortened spine, and the extreme bowing of both thighs (Fig. 2). The skull was neither large nor irregular. The patient did not appear ill, but lay perfectly flat in bed; the slightest attempt at motion, either active or passive, caused her to cry out with pain. All bones were extremely tender. Otherwise, the findings were normal for a woman of her age, except for a moderately advanced senile dementia.

Her pain was so severe that anaesthesia was necessary before roentgenograms could be taken. At that time it was noted that, when the right foot was elevated, the entire right lower extremity hung between the foot and the pelvis like a piece of rubber hose, and that the extremity could easily be twisted in any direction. The roentgenograms revealed spectacular changes in many bones. The skull and right humerus still exhibited the thickening, irregular density, and trabeculation so typical of Paget's disease. There was extreme osteoporosis of the pelvis and lumbar spine with collapse of the latter (Fig. 3). The same osteoporosis was present to an even greater degree in the femora, both of which showed multiple unhealed fractures (Fig. 4-A). The left leg was relatively normal, but in the right the tibia was almost invisible, while the patella, fibula, and foot were quite dense (Fig. 5-A). Other bones showed no more change than would be expected after three and one-half years in bed.

Of the many preliminary studies which were done, none showed significantly abnormal findings. These included several tests of liver and kidney function, glucose tolerance, pH of urine, skin-temperature readings, et cetera. The basal metabolic rate was plus 50, but, since the patient was nervous and uncooperative, this reading, although repeated several times, may be questioned. There were no signs or symptoms suggestive of hyperthyroidism.

Representative values for blood chemistry are given below. These values remained relatively constant throughout the patient's hospital stay, except for those which will be mentioned specifically.

Calcium	9.95 to 11.86	milligrams per 100 cubic centimeters
Phosphorus	2.80 to 3.75	milligrams per 100 cubic centimeters
Sodium	130.6 to 145.7	milli-equivalents per liter
Potassium	2.99 to 4.76	milli-equivalents per liter
Chloride	100.8 to 103.5	milli-equivalents per liter
Carbon dioxide	26.3 to 27.2	millimoles per liter
Total protein	5.9 to 7.5	grams per 100 cubic centimeters with normal albumin-globulin ratio
Non-protein nitrogen	29 to 40	milligrams per 100 cubic centimeters
Lipids	843	milligrams per 100 cubic centimeters
Cholesterol: Total	198	milligrams per 100 cubic centimeters
Free	159	milligrams per 100 cubic centimeters
Serum pH	7.5	
Alkaline phosphatase	75 to 85	King-Armstrong units

During this preliminary period, the average daily excretion of calcium in the urine was 48 milligrams. The significance of this and of subsequent determinations will be discussed later.

With the use of local anaesthesia, pieces of the skull, one rib, and the right tibia were removed for microscopic examination. There was so little bone in the right leg that the needle penetrated the cortex. The bone was identifiable, but was so soft that it could be compressed by the slightest digital pressure. The specimen was scooped out with the handle of a knife. The rib and the skull were soft, but not to the same degree as the tibia.

Microscopic section (Fig. 6-A) shows the atrophic bone of the skull. Although there are too few remaining trabeculae to permit a definite diagnosis, the irregular cement lines and the suggestion of a mosaic pattern are compatible with the picture of Paget's disease. Osteoblasts and osteoclasts are both present in the usual numbers. Osteoid tissue can be identified in many places, but it is nowhere abnormal in quantity. The marrow is primarily fatty with small islands of hematopoietic tissue. In many places, especially near bone trabeculae, the marrow is oedematous, but it never shows the fibrous-tissue replacement and collections of giant osteoclasts so typical of hyperparathyroidism.

The section of the tibia (Fig. 7-A) shows much more spectacular loss of bone substance. This section represents the entire thickness of the cortex and periosteum. As in the skull, there is no lack of osteoblasts or osteoclasts; and the marrow, except for some oedema, is unremarkable. Sections from the rib showed atrophic bone with active hematopoietic marrow.

Of the diagnoses which had been entertained at first, two were now considered to be eliminated. The normal blood calcium and phosphorus, the presence of a low urine calcium, the lack of response to parathyroidectomy, and the absence of characteristic

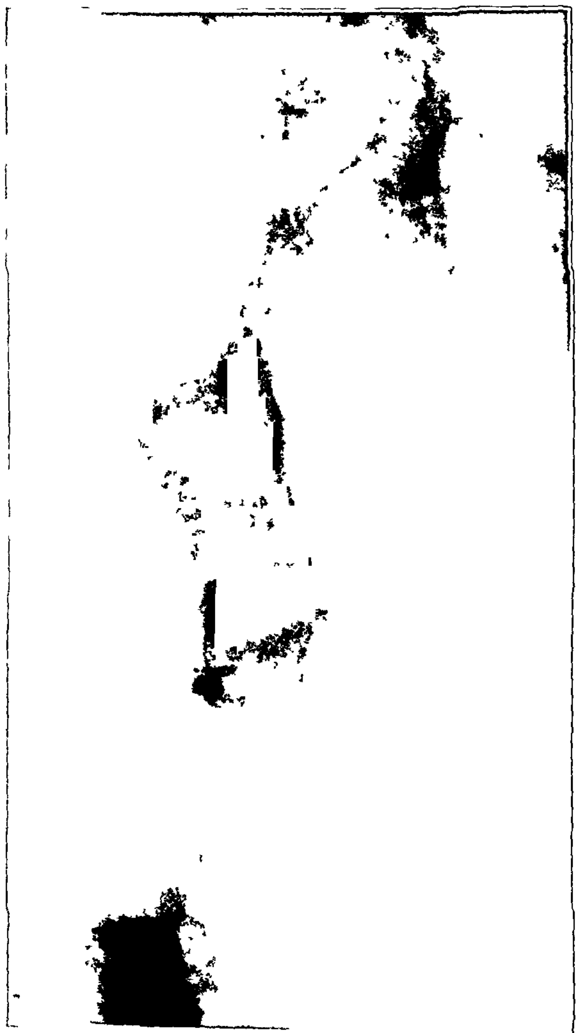

Fig 4-A

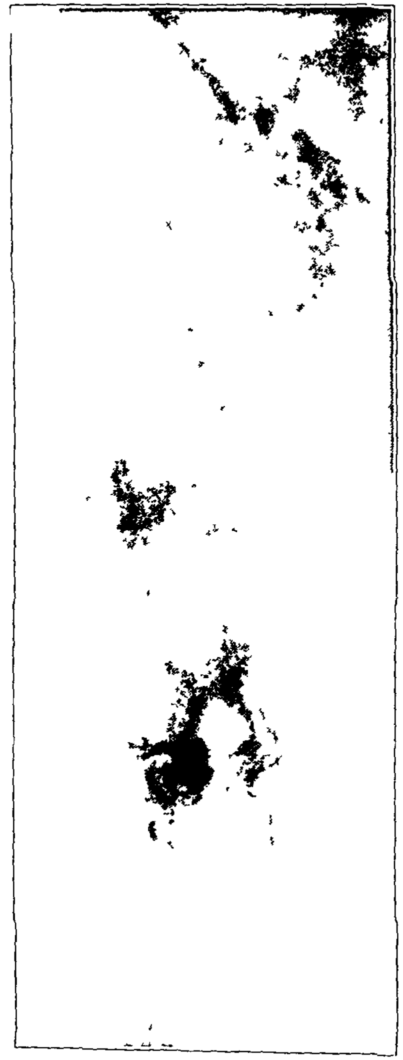

Fig. 4-B

Fig. 4-A: Roentgenogram of right femur, four years after onset of symptoms. Soft-tissue technique has been used to demonstrate the bone, which is only slightly more dense than the muscles. Several unhealed fractures are present.

Fig. 4-B: Right femur after estrogen therapy. The fractures are all healed with abundant callus, and trabeculation is much more evident. Soft-tissue irradiation technique is no longer necessary to demonstrate the bone.

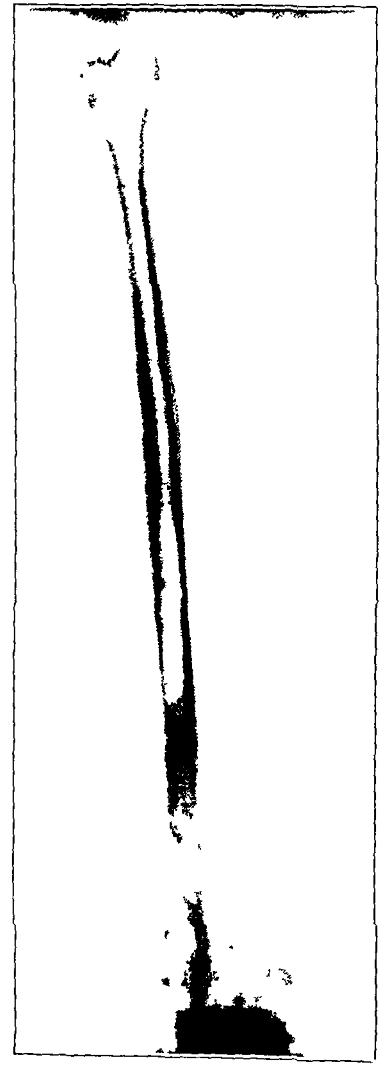

Fig. 5-A

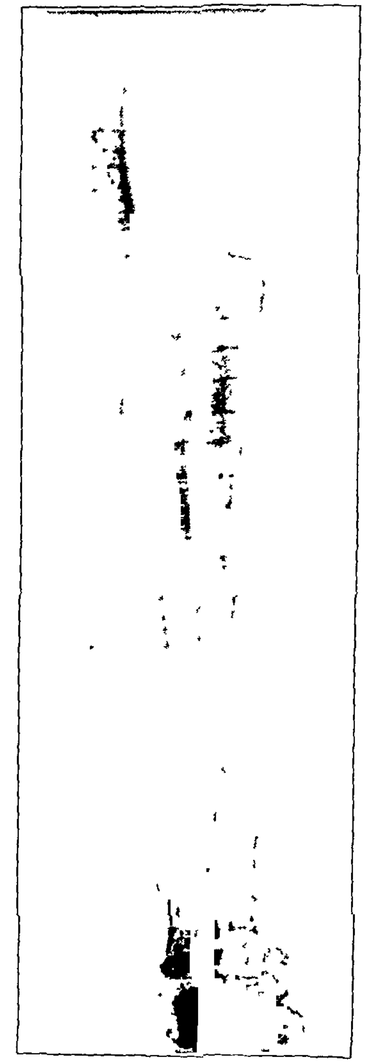

Fig. 5-B

Fig. 5-A: The same soft-tissue technique has been used to demonstrate the remains of the right tibia, which is barely distinguishable.

Fig. 5-B: Roentgenogram of right leg, after twenty-eight days of therapy with estrogens. The right tibia is now clearly outlined and irregular trabeculation is visible throughout. Irradiation has been heavier (as shown by the appearance of the fibula and soft tissues). The fibula is free [illegible] Paget's disease and re-

histological findings made the existence of either hyperparathyroidism or osteomalacia most improbable.

The history of slowly progressive bowing of the lower extremities followed by pathological fractures, the roentgenographic appearance of the skull and humerus, and the persistently elevated alkaline phosphatase were all compatible with the diagnosis of Paget's disease. However, it was difficult to explain the extreme bone atrophy on this basis alone.

Albright and his associates have pointed out that the so-called "idiopathic osteoporosis" occurs almost exclusively in women of menopausal age. It is seen also in younger women who have had an artificially induced menopause. In all cases it involves primarily the pelvis and spine, to a much smaller degree the long bones, and the skull least of all [1, 36].

The patient described here had had a surgical menopause seventeen years before her bone disease became disabling. Many of the symptoms and findings, although much more extensive than those of recorded cases, were similar to those of Albright's patients. The diagnosis of postmenopausal osteoporosis could not explain the markedly elevated phosphatase level, however, or the roentgenographic appearance of the skull. Moreover, it is hard to conceive of a generalized process which would spare one tibia while the other practically disappeared, without the fibula being involved, and affect the lumbar spine and pelvis so severely, while the rest of the trunk remained relatively normal. On the other hand, the microscopic preparations could not truthfully be said to show anything but extreme atrophy.

Taking all these facts into consideration, we concluded that the spectacular picture presented by this patient could best be interpreted as a severe postmenopausal osteoporosis, superimposed upon a previously existing widespread Paget's disease. The pe-

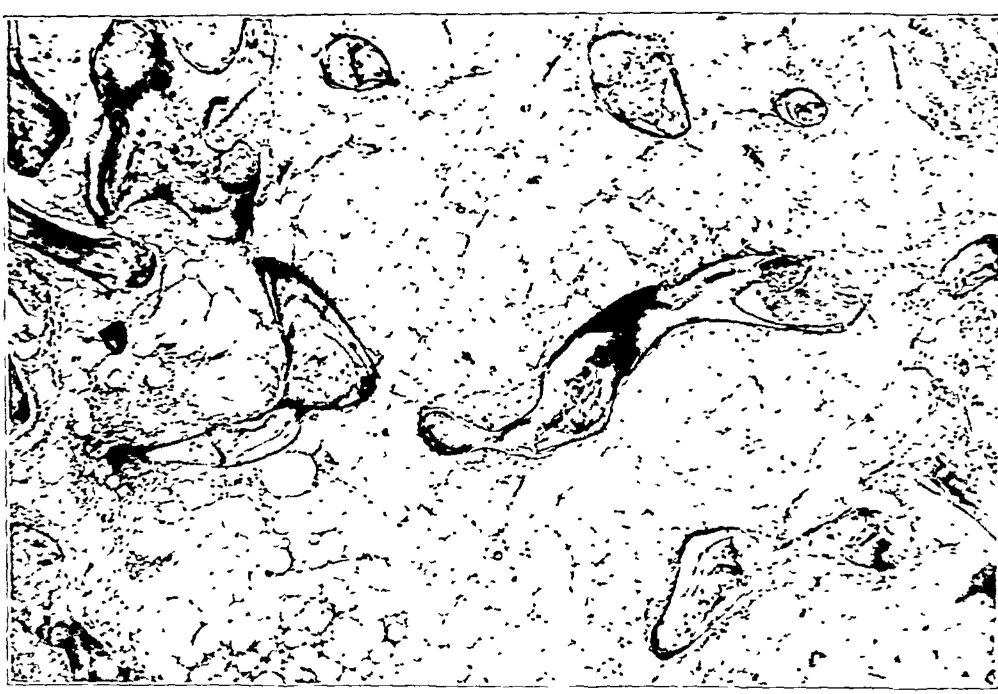

Fig. 6-A

Photomicrograph (× 50) of bone of the skull before any therapy was given. Trabeculae are too atrophic and scarce to permit a definite diagnosis, but there are prominent cement lines and a suggestion of mosaic pattern. Osteoid tissue is present in small amounts. Both osteoblasts and osteoclasts appear in the usual numbers. The marrow is slightly oedematous, but otherwise normal

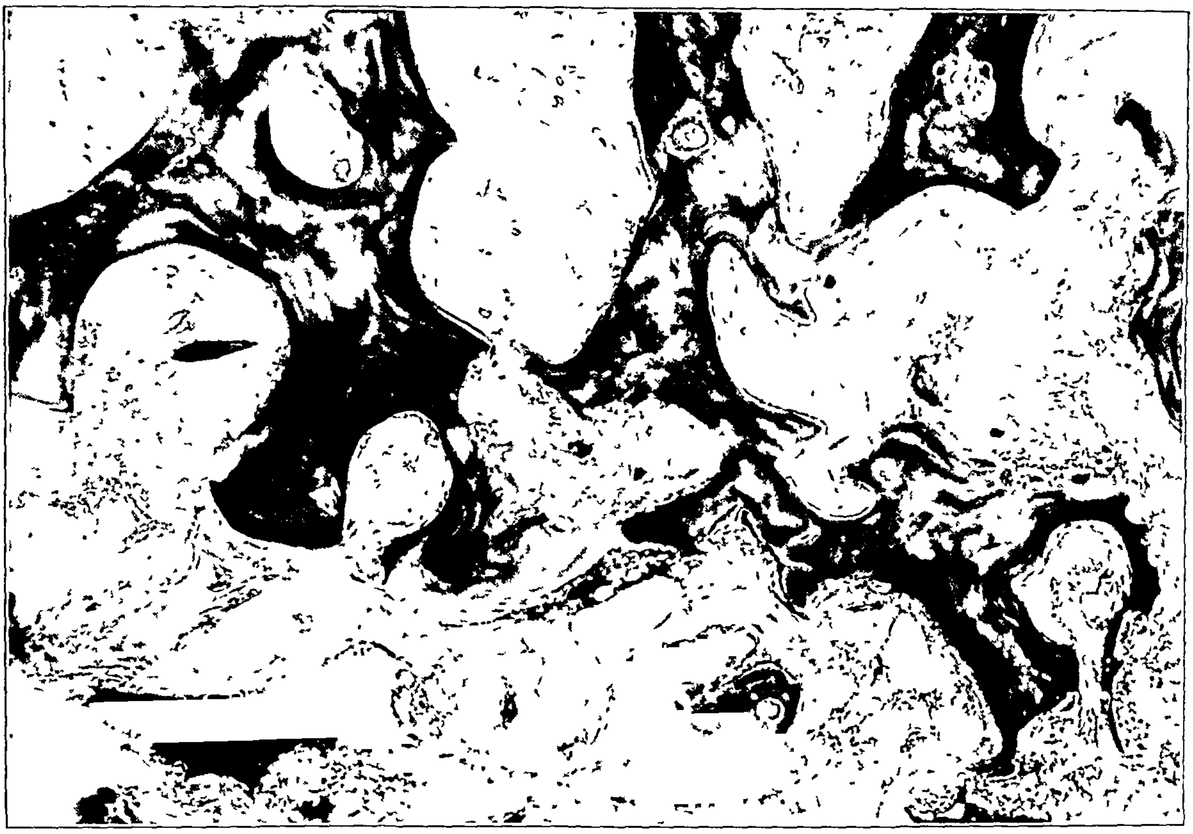

FIG. 6-B

Bone of same area of skull (× 52) after estrogen therapy. There is an obvious increase in the number and thickness of trabeculae, with many active osteoblasts and osteoclasts. The fibrous marrow at the right is the result of previous operative interference. Note large blood spaces.

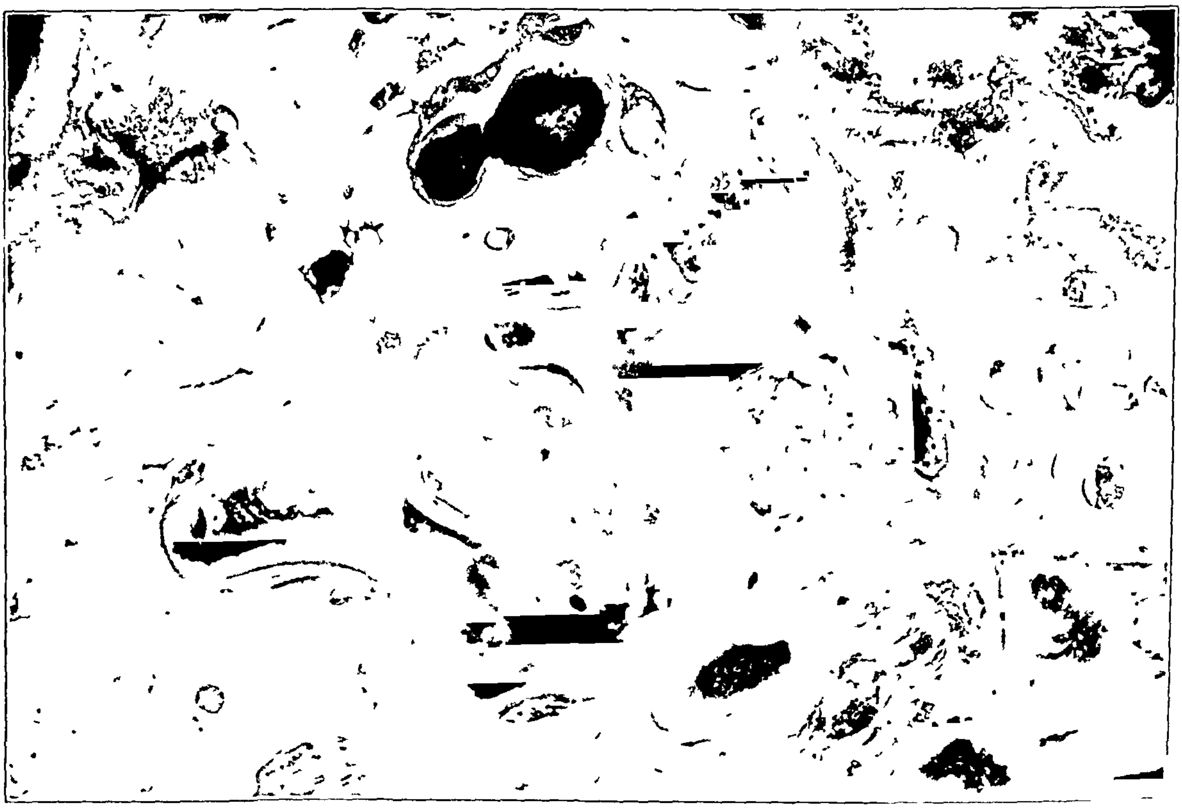

FIG. 6-C

Silver stain of bone of skull (× 50), showing that much of the new tissue is not yet calcified. The osteoid borders are much wider than normal. (Patient had had estrogens, but no calcium or vitamin D.)

FIG. 7-A

Photomicrograph (× 113) represents the entire tibial cortex before therapy. As in the skull, there are active bone-forming and bone-destroying cells with a relatively normal marrow. The picture is that of extreme atrophy.

culiar distribution of the lesions could also be explained by this combination of disorders. The degree of bone atrophy from any cause is proportional to the available blood supply. Thus, when necrosis of bone has occurred and there is no circulation, atrophy cannot proceed at all, and the dead bone retains its original density. On the other hand, when a limb is immobilized so that atrophy of disuse is established, the greatest degree of osteoporosis is seen in the metaphysis, where there is the largest blood supply [2]. Paget's disease of bone is accompanied by an increased circulation, which often is sufficient to raise the temperature of the overlying skin. Thus it is conceivable that the ordinary process of postmenopausal atrophy, when it evolves in a bone which is already the site of an active Paget's disease, is greatly augmented both in rapidity and in degree.

With this diagnosis, it was decided to treat the patient with massive doses of estrogenic hormone. During this period and for three months preceding it, she was given the regular house diet with no added calcium or vitamin D. She had a total of 610,000 rat units (101.3 milligrams) of estradiol benzoate in twenty-eight days. Within the first three days, marked subjective improvement began. The bone pain diminished; the patient began to be active; and her general attitude, from one of extreme apathy, began to be more normal. Within a week, she could be moved without discomfort, and the spontaneous bone pain had disappeared. At the end of a month, she was able to sit in a chair and manage her meals by herself. Her limbs no longer felt soft, and there was palpable callus about many of the fractures. Roentgenograms taken at this time showed surprising changes. The right tibia was now clearly outlined, and there were definite trabeculae throughout its length (Fig. 5-B). Both femora were increased in density, and about the many fractures there was exuberant, fairly dense callus (Fig. 4-B). Similar increased density was evident in the pelvis, but the rest of the bones appeared unchanged.

Biopsy studies were repeated with material from the same areas which had been examined before. On this occasion, the bone of the tibia was found to be sufficiently dense and resistant so that an osteotome was necessary to cut it.

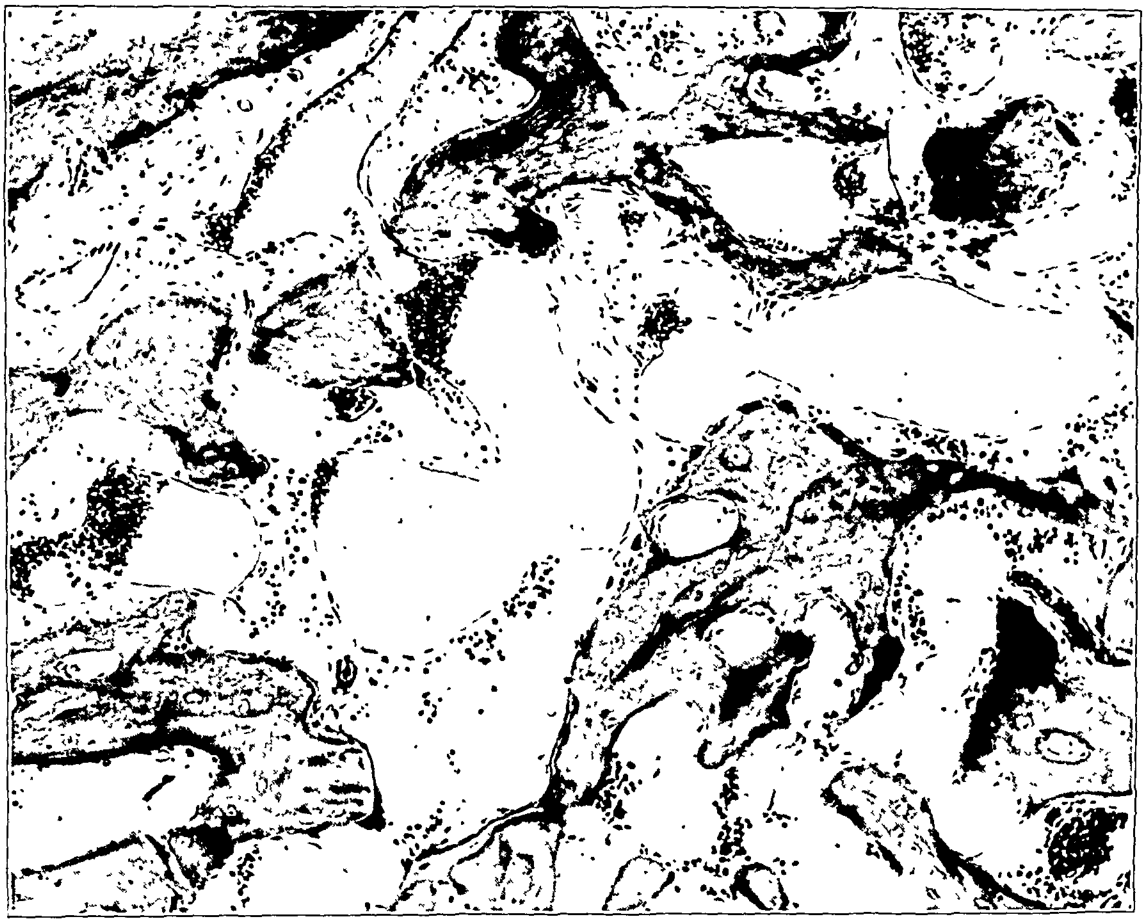

FIG. 7-B

Same area of the tibia after estrogen therapy (× 100). There is a large amount of new bone of somewhat irregular pattern. As in the other sections, large blood spaces are prominent.

The bone taken from the tibia (Fig. 7-B) shows the generalized increase in number and thickness of the bone trabeculae. Many surfaces are completely covered by osteoblasts, while others have numerous osteoclasts. The chief change in the marrow is the presence of many very large blood spaces, a finding which has been noted in some experimental animals [46]. The same changes can be seen in bone from the skull (Fig. 6-B). A silver stain shows that not all of the new lamellae are calcified (Fig. 6-C). The osteoid seams, present about many trabeculae, are definitely wider than those normally seen. That these changes occurred also in normal-appearing bones is demonstrated by Figure 8. This section, taken from a rib, shows a large plaque of immature new bone on each side of an atrophic trabecula. The active hematopoietic marrow is normal.

It was, unfortunately, not possible to study this patient's calcium metabolism with any accuracy. She was not only incontinent of both urine and feces, but she had sufficient cerebral deterioration so that adequate management of a catheter was impossible. However, an attempt was made to get an approximate estimate of her urine-calcium excretion. Since the collections were never complete, all twenty-four-hour values which could be obtained for each period were averaged. Inaccurate though they are, these averages are worth recording.

Initially, before the patient was given any medication and while she was on the regular house diet, twenty-one collections were made. The average volume of urine was 814 cubic centimeters, and the calcium was 48 milligrams. During the period of her spectacular improvement, when she was receiving 30,000 rat units (4.98 milligrams) of estradiol daily, only seven representative collections were obtained. These gave an average volume of 564 cubic centimeters and a calcium level of only 26 milligrams. The third measured period lasted for thirty days, during which she received daily 20,000 to 30,000 rat units (3.32 to 4.98 milligrams) of estradiol benzoate, 4 grams of calcium, and 50,000 units of vitamin D. The average urine volume was 708 cubic centimeters and the calcium was 60 milligrams. Immediately thereafter was a period when all medication was discontinued, and twenty-four samples gave an average urine volume of 581 cubic centimeters with 150 milligrams of calcium. Following this, 4 grams of calcium and 50,000 units of vitamin D were added each day. By this time, the patient had been without estradiol for two months, and her symptoms began to recur with such alarming rapidity that this period had to be stopped with only eleven samples.

The average urine volume was 792 cubic centimeters and the calcium was 210 milligrams. The final period is represented by forty-four samples, collected when the patient was receiving daily 20,000 to 40,000 rat units (3.32 to 6.61 milligrams) of estrogens, 4 grams of calcium, and 50,000 units of vitamin D. The average urine volume was 650 cubic centimeters and the calcium was 104 milligrams (Chart I).

Since the patient excreted a considerable amount of calcium in her urine even when her skeleton was extremely depleted, it is probable that the primary defect was not lack of absorption of calcium by the gut (as in osteomalacia, insufficient ingestion of calcium, or sprue) [12, 13, 22, 30, 31, 32]. This conclusion is supported by the microscopic sections, which did not show excessive amounts of osteoid tissue until osteoblastic activity had been stimulated in the absence of increased ingestion of calcium and vitamin D. When the patient received large amounts of added calcium and vitamin D (given to increase intestinal absorption), together with estradiol, she excreted very little more calcium, which suggests that she was retaining most of it; of course, without values for fecal calcium, this cannot be proved. However, when the estradiol was withdrawn but the calcium and vitamin D continued, the calcium in the urine rose to almost four times its previous values, which would indicate that absorption was maintained but retention was decreased. In the final period, when estrogens were reinstituted, the urine calcium again decreased, as it should if retention were stimulated.

The subsequent course of this patient has been most interesting. Following her relapse when medication was discontinued, the administration of estrogens was resumed, and an attempt was made to discover her maintenance dose. It was found that on anything less than 2,000 rat units (0.33 milligram) daily, her bone pain tended to recur. She has, therefore, been maintained for over two years on this dose, with a rest period of one week in every six or eight.

During this time, the only evidence of general estrogenic effect has been the patient's

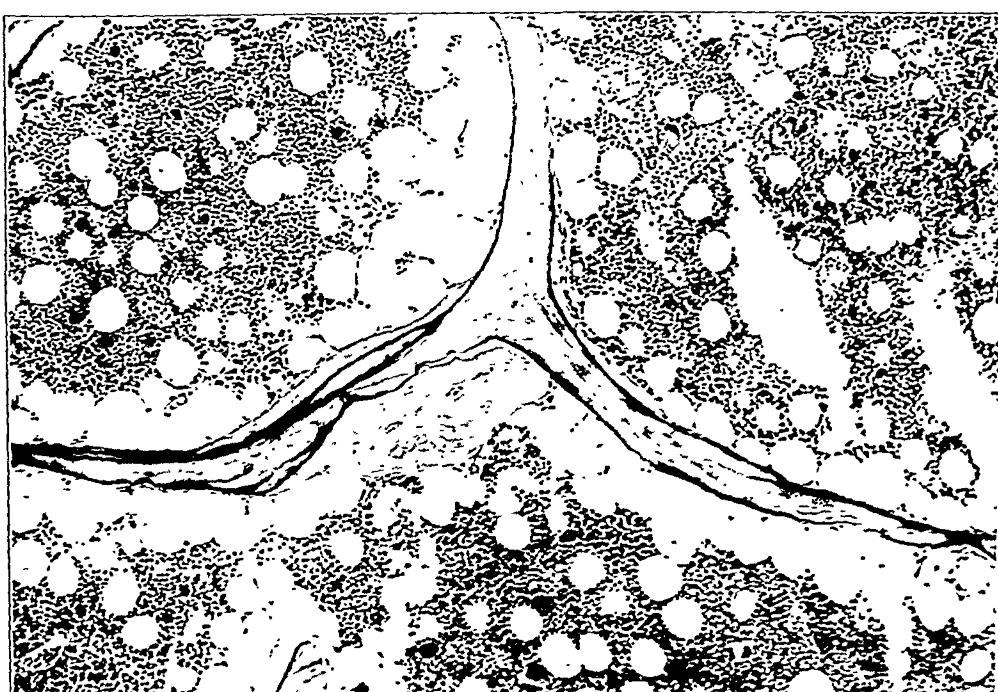

FIG. 8

Photomicrograph (× 100) of section from rib after therapy with estrogens. There is a large plaque of immature new bone on both sides of the atrophic trabeculae. Normal active hematopoietic marrow is present.

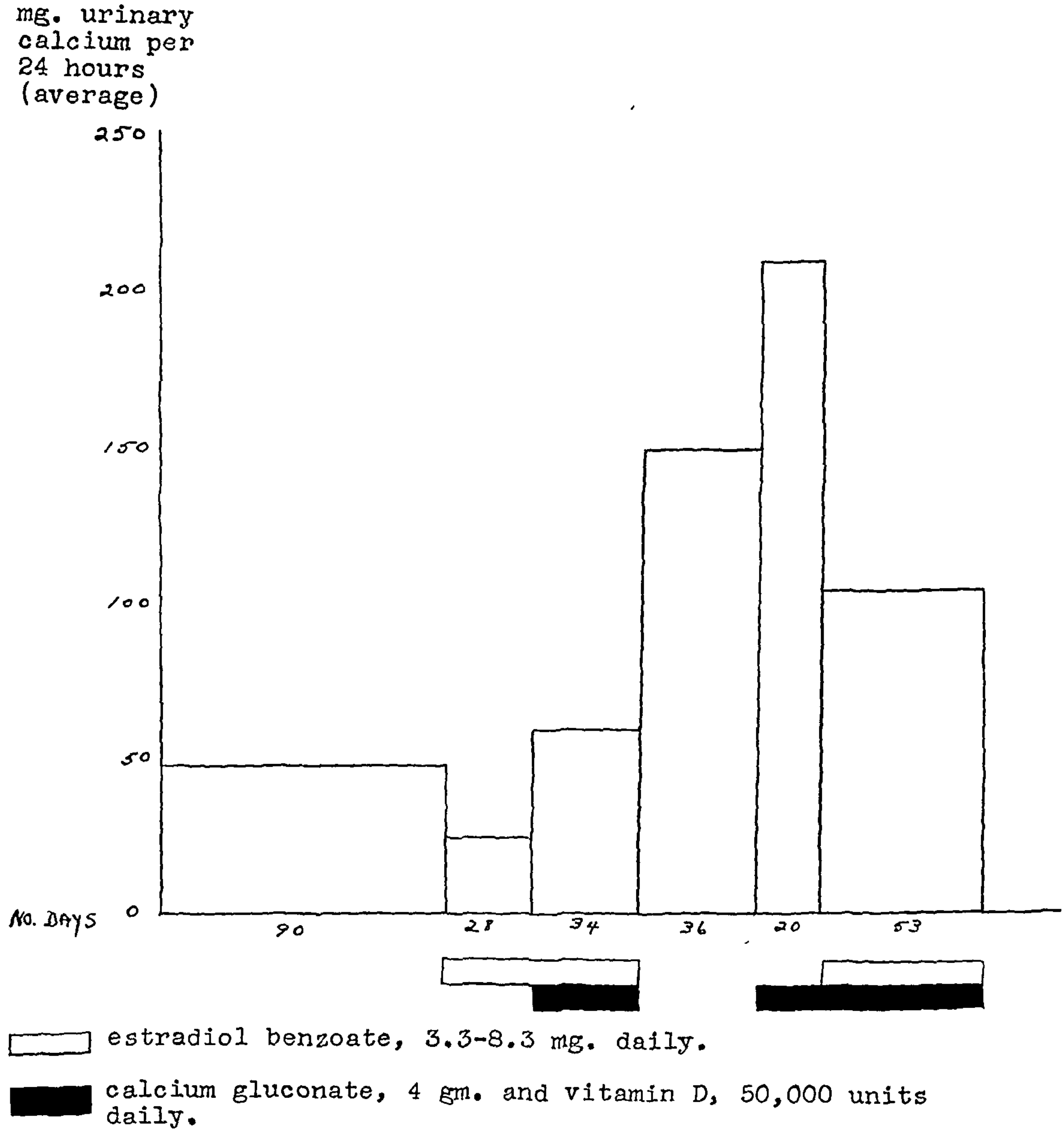

CHART I

Effect of estradiol benzoate on urine-calcium excretion. During all of this time the measured *dietary intake of calcium was 950 to 1,000 milligrams daily.*

increased feeling of well-being. There was never a noticeable effect on breasts or genitalia, or a significant change in her blood count. (Toxic effects from large doses of estrogen have been noted in the blood and marrow of rats and dogs [11, 15, 51, 54], but not in monkeys [15, 52].)

Although her blood lipids were always within normal limits, they did rise from 843 to 936 milligrams per 100 cubic centimeters. The cholesterol levels showed a much more marked change. Before any therapy had been given, the total cholesterol level was 198 milligrams per 100 cubic centimeters (the free cholesterol was 159 milligrams). These values gradually rose to 528 milligrams of total and 437 milligrams of free cholesterol, where they remained until estrogens were discontinued. The values then fell gradually to 328 milligrams of total and 241 milligrams of free cholesterol. When estrogens were resumed in smaller doses, the values remained between 328 and 476 milligrams of total and 240 to 280 milligrams of free cholesterol. This observation is consistent with the experimental findings in ducks, sparrows, doves, and monkeys [23, 29, 35]. This tendency has been observed by us in a few other clinical cases, but no conclusive data have yet been obtained.

There has been no evidence, either clinical or roentgenographic, of a tendency of

the bone to resorb except when estrogen was discontinued. This is at variance with the findings of the Silberbergs and others, who observed a decrease of new bone, produced by injected estrogen, when the hormone was maintained over long periods [7, 48].

It has been noted repeatedly that the simultaneous administration of testosterone propionate seems to increase the estrogen-induced new-bone formation in birds [9, 36]. On the other hand, in mammals, the result of the addition of testosterone seems to be to neutralize the effect of the estrogen [19, 20, 21]. The patient described here was given testosterone with the estrogen for approximately six weeks, in doses of from 0.010 to 0.0125 gram daily. There was no perceptible change in the clinical or roentgenographic picture. This is, of course, difficult to evaluate for, while the change from almost no bone to some bone is easily detected by roentgenogram, the change from some bone to a little more or less bone is practically impossible to measure.

As noted before, the initial basal metabolic rate in this patient was always about plus 50. The accuracy of the readings is open to question because of the patient's extreme pain and apprehension. However, two readings of plus 45 and plus 50 were obtained after her marked improvement had begun, at a time when she was quiet and cooperative. Thereafter, the readings fell steadily (no specific medication being given) until they reached and maintained a level of plus 14 to plus 20. This is interesting in the light of the finding of Sherwood and his associates that the administration of estrogen causes a fall in the basal metabolic rates of rabbits and rats, if the thyroid gland is present. Observations on five women who had undergone panhysterectomy gave variable results (increase, decrease, and no effect) [14].

There was never any demonstrable change in blood pressure, heart rate, or respiration, which is in accord with the few experimental observations made [33, 34].

SUMMARY

In a woman of fifty-eight years, many of whose bones had almost disappeared as a result of Paget's disease, together with a severe postmenopausal osteoporosis, massive estrogen therapy was followed almost at once by a remission of clinical symptoms and by actual reconstitution of bone. Withdrawal of the estrogen produced an exacerbation; its readministration was again followed by improvement. For over two years the patient has been kept on daily doses of from 2,000 to 10,000 rat units (0.33 to 1.66 milligrams) of estradiol benzoate; during this time she has maintained her improvement and has showed no untoward symptoms.

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DISCUSSION

DR. A. R. SHANDS, JR., WILMINGTON, DELAWARE: The case Dr. Sherman has reported is a remarkable one. I have had no personal experience in the use of estrogens in bone formation. Certainly the report of this case will make many of us think of patients whom we should have treated in a similar way. I am sure very few orthopaedic surgeons have used estrin. Perhaps we have been frightened by reports of secondary sexual changes associated with its use, as well as other complications. The continued massive doses, used by Dr. Sherman in this patient over a period of two years to relieve pain and cause recalcification and healing of fractures, have certainly produced a most remarkable result. Perhaps in these cases it might be helpful if there was some way of determining an estrin deficiency beforehand, so that the hormone could be given as a preventive measure.

The steroid-producing endocrine glands—namely, the male and female gonads—and the adrenal cortex, are interesting to read about in Dr. Fuller Albright's publications. Once we fully appreciate their mechanism in the body and the significance of their secretions, we will undoubtedly understand much more about osteoporosis and many other bone conditions. We certainly hope that this work of Dr. Albright will show how to use, intelligently and safely, estrogen, testosterone, and adrenal-cortex extracts.

In our hospital we have been particularly interested in the osteoporosis associated with the nephrotic child. The work on nephrosis forms a part of our program of research under Dr. Lee E. Farr, director of research. A thinning of the cortex of the bones of these children is always found, indicating a calcium imbalance. Dr. Farr has observed and treated approximately 125 of these cases. Dr. Albright and others are of

the opinion that with loss of serum albumin, which is an important nitrogenous precursor of bone matrix, there is a decrease in the bone production. In these cases which Dr. Farr has treated, the serum albumin varied from 10 to 75 per cent. below normal. Emerson and Beckman, working at the Rockefeller Hospital, reported in detail, in 1945, three cases of a diffuse rarefaction of the shafts of the bones, with normally dense epiphyseal lines. It was their belief that there was a generalized decalcification of the skeleton, indicative of abnormal calcium metabolism. Apparently in these cases there is an excessive loss of calcium in the faeces and a diminished loss in the urine; and, with the lowering of the serum-calcium concentration, a parallel decrease occurs in the serum-protein level. These factors have been noted as early as one month after the onset of the disease. However, in these nephrotic children, the skeletal growth and the supply of calcium in the epiphyses are apparently normal. Nevertheless they fail to retain the calcium at a rate even remotely approaching the retention rate of normal children. With this failure to store calcium at a normal rate, a skeletal decalcification results which can always be seen in a roentgenogram. In one of the cases of Emerson and Beckman, a child had a remission of signs and symptoms of nephrosis and then had a prompt return to normal calcium metabolism.

For the last two years, work has been going on in our laboratories, under the supervision of Dr. Farr, on the "protein content of bone", the actual work being done by Dr. Strobino and Dr. Rosenblum. Some of this work was reported by me at The American Orthopaedic Association meeting last year. Since that time Dr. Strobino has analyzed the protein content of twenty-five human bone specimens. (The original work, as you may remember, was done on beef bone.) One of these human bones was the tibia of a man, thirty-five years old, who had an amputation in the mid-thigh for an ununited fracture of the femur, which had become infected and in which osteomyelitis had developed. The exact length of time between the accident and the amputation is not recorded. It was quite definite from the roentgenograms that this tibia had undergone osteoporosis, presumably from disuse. The protein content was definitely lower than in the tibiae of two comparable senile patients (seventy-two and seventy-three years old). The ash value was the same. However, if the observations of Baker and co-workers in 1946 are correct, that the protein matrix and calcium are removed together in osteoporosis, one would not expect a lower protein content. Actually, this osteoporotic tibia showed a protein content of 28 per cent. and an ash content of 63.9 per cent.

In conclusion, I wish to present, through the courtesy of Dr. O. N. Stern of Wilmington, Delaware, one remarkable case of a newborn baby with almost complete "anossification". (I use the word "anossification" for want of a better term.) A complete report of this case is now being prepared for publication by Dr. Stern The mother was thirty-seven years old and had been married ten years; there had been no children. Th pregnancy lasted eight and one-half months. There was normal labor, with a brow presentation. Just befor labor began, the first roentgenograms of the pelvis were made. While the mother was in labor and the ob stetrician was in the delivery room, word came from the X-ray Department that the roentgenograms showe no evidence of a foetus *in utero*. Of course, this was quite disturbing to the obstetrician. However, a six pound child, twenty-four centimeters long, without gross congenital malformations, was delivered. Befor birth the foetal heart sounds had been normal and there had seemed to be normal activity of the foetu *in utero*. The child lived for four hours. At autopsy, the baby showed a bilateral atelectasis, and the roent genograms showed only slight evidence of ossification in the clavicles.

Following labor, biochemical studies were done on the blood of the mother. The calcium was 10 milli grams per 100 cubic centimeters, the phosphorus 4.5 milligrams per 100 cubic centimeters, the cholester 310 milligrams per 100 cubic centimeters, and the basal metabolic rate minus 12 per cent. The obstetrician advised the mother to wait three months before becoming pregnant again. At the end of this period she became pregnant for the second time; and in nine months a normal baby, with a normal skeleton, was delivered.

Apparently no similar case has been reported in the literature. I regret that I do not have sections of the tissue which replaced the bone matrix in the skeleton. These will be shown when the case is reported. Perhaps this foetus did not receive the necessary estrin to cause calcification. Dr. Sherman might like to comment on this possibility.

DR. MARY S. SHERMAN (closing): I am afraid I cannot answer Dr. Shands' question as to why there was no calcification of the bones of the baby.

STREPTOMYCIN IN THE TREATMENT OF CHRONIC INFECTIONS OF BONE

BY CAPTAIN JOHN C. WILSON, JR.
Medical Corps, Army of the United States

From the Orthopaedic Section of the Surgical Service, Percy Jones General Hospital, Battle Creek, Michigan

During the three years which have elapsed since the termination of World War II, the attention of many physicians has been turned toward the treatment of the chronic infected wound involving bone. Despite many recent advances, the treatment of chronic osteomyelitis continues to present formidable problems. A review of the literature reveals many methods of treatment which have been attempted with varying degrees of success. In World War I the Carrel-Dakin treatment was advocated. In later years, various forms of wound sterilization were described, including zinc solutions, urea, maggots, allantoin, bacteriophage, and many others. In 1923, Orr published his classical paper in which rest was offered as the fundamental concept of treatment, as well as thorough débridement and infrequent dressing. During World War II the morbidity and mortality from compound wounds involving bone were diminished strikingly by the use of antibiotic preparations, especially sulfadiazine and penicillin. The increasing availability of streptomycin for clinical use has made possible still further improvement in the therapy of certain types of chronic infections of bone.

The purpose of this clinical study has been to determine whether or not the use of systemic and local streptomycin, in addition to thorough sequestrectomy and meticulous wound care, would hasten the healing of wounds in patients ill with osteomyelitis of long duration. For this study, patients were chosen who presented certain specific clinical criteria. In all patients the diagnosis of osteomyelitis was substantiated by pathological, roentgenographic, and clinical evidence. All had chronic discharging sinuses which led to bone. Purulent drainage had persisted for an average of nineteen months and had confined these patients not only to a hospital, but in almost all cases to a life in bed. In all but two patients, predominantly gram-negative organisms were cultured from the exudate of the sinus tracts.

These patients had run the gamut of treatment for chronic septic bone disease. Some had had as many as twelve sequestrectomies. All had endured many courses of Orr treatment. Their clinical charts reveal the administration of millions of units of penicillin over the course of many months. On one, an acrylic implant had been used unsuccessfully to fill a defect in bone. On others, muscle flaps had been transferred and innumerable Thiersch grafts had been applied to granulating surfaces. The wound-sterilizing agents which were employed are too numerous to record, but they include all possibilities from azochloramid to zinc chloride. Despite these efforts, the disease progressed and the chronicity of the osteomyelitis went unchecked. Associated with a long period of hospitalization was a mental depression of greater or lesser degree, caused by protracted separation from families and by a fear that prolonged absence from the routines of healthful living would make a readjustment to civil life exceedingly difficult.

In an effort to heal these patients, a plan of therapy was evolved, based upon four well-established surgical principles:

1. A thorough investigation of the bacterial flora of the wound, and the determination of sensitivity of the organisms to streptomycin and to penicillin;
2. A radical sequestrectomy with saucerization of the wound, after adequate preparation of the patient;
3. The use of streptomycin and penicillin prior to, during, and after surgery;

TABLE I

SITE OF INFECTION IN TWENTY-FIVE CASES

Bones Affected	Number of Cases
Femur	11
Tibia	8
Humerus	2
Radius	1
Tibia, fibula, talus, and calcaneus	1
Acetabulum and head of femur	1
Sacrum and ilium	1
Total	25

4. Meticulous postoperative wound care to prevent contamination from individuals, from other wounds, and from the environment.

Twenty-five patients were treated. All were white males whose average age was 27.6 years. The oldest was thirty-nine; the youngest was nineteen. Twenty-four of the patients had sustained compound injuries, involving bone, when in the front lines of combat or in areas directly adjacent to them. In one patient hematogenous osteomyelitis developed, which progressed to a degree where clinically it was impossible to differentiate his disease from that of the others. The affection in the majority of cases was confined to the long bones of the lower extremity (Table I).

The first requirement for treatment was satisfied by taking a culture from the depths of the sinus tract under aseptic technique. The skin edges were separated with a sterile instrument, and a cotton swab was introduced until bone was felt. In this way organisms were obtained from the infected area itself and not from the skin. The bacteria were then cultured and isolated, and sensitivities to streptomycin and to penicillin were obtained.

Characteristically, the gram-negative organisms were insensitive to penicillin. Occasionally, a hemolytic *Staphylococcus aureus* was cultured, which was resistant to penicillin but very sensitive to streptomycin. For this reason a sensitivity to each drug was obtained on gram-positive organisms.

If bacteria were sensitive to 16 micrograms or less of streptomycin per cubic centimeter of media, the systemic use of the drug was considered advisable. However, if the sensitivity proved greater than 16, local streptomycin was used and none was given by the intramuscular route.

The bacterial flora was mixed in all cases but two. *Proteus vulgaris*, the most common gram-negative organism found, was present in nineteen of the patients (Table II). The hemolytic *Staphylococcus aureus*, coagulase positive, was the most common gram-positive organism cultured; it was present in nineteen of the cases (Table III).

TABLE II

GRAM-NEGATIVE ORGANISMS

Organism	Number of Cases
Proteus vulgaris	19
Pseudomonas aeruginosa	13
Escherichia coli	8
Paracolon organisms	5
Alcaligenes faecalis	4
Aerobacter aerogenes	3
Pseudomonas fluorescens	3

TABLE III

GRAM-POSITIVE ORGANISMS

Organism	Number of Cases
Hemolytic *Staphylococcus aureus*, coagulase positive	19
Anaerobic streptococcus	5
Staphylococcus albus	4
Beta-hemolytic streptococcus	2
Diptheroids . .	2
Gamma streptococcus .	2
Streptococcus viridans .	1
Sarcina	1

The origin of the bacterial infection is problematical. The majority of the men wounded in combat gave a history of falling to the ground at the time of injury. Some recall their physicians telling them that dirt, wood, clothing, or metal had been removed from the wounds at the time of débridement. Others recall a foul-smelling green exudate which permeated their plaster-of-Paris casts two or three weeks after the injury. Some of the organisms may have lived in the wounds since the time of initial injury; however, we believe that most are contaminants.

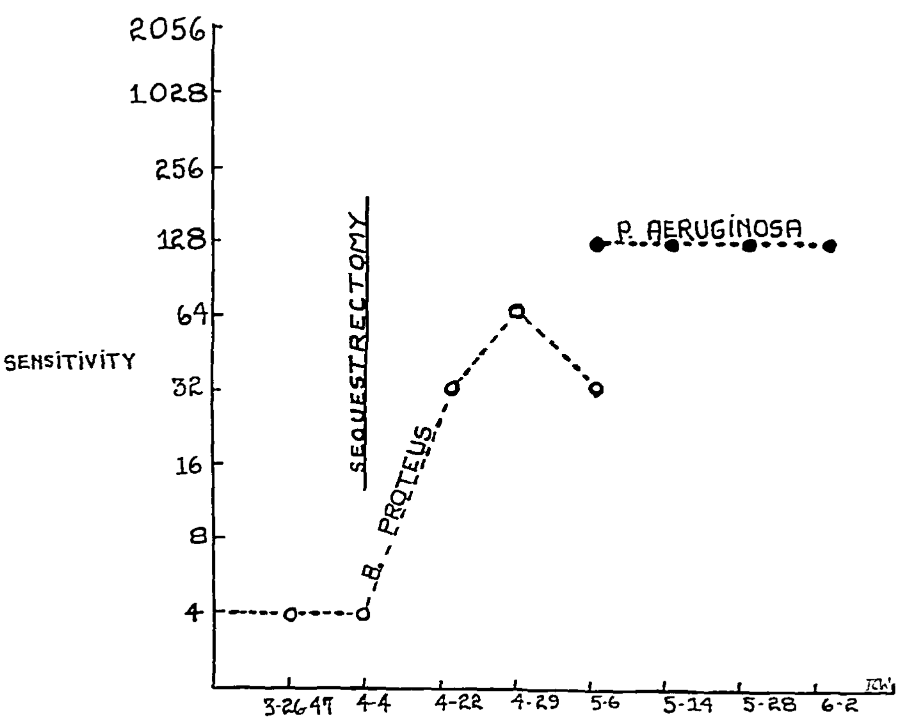

CHART I

This graph shows the rapid development of resistance by *Bacillus proteus* following the administration of streptomycin.

While the necessary bacteriological data were being compiled, preparation of the patients for surgery progressed. All of them received high-caloric diets, supplemented by the oral administration of vitamins and by iron preparations when indicated. Severe anaemias were corrected by transfusions of whole blood. In cases of suspected hypoproteinaemia, determinations of total protein and albumin-globulin ratio were obtained. If

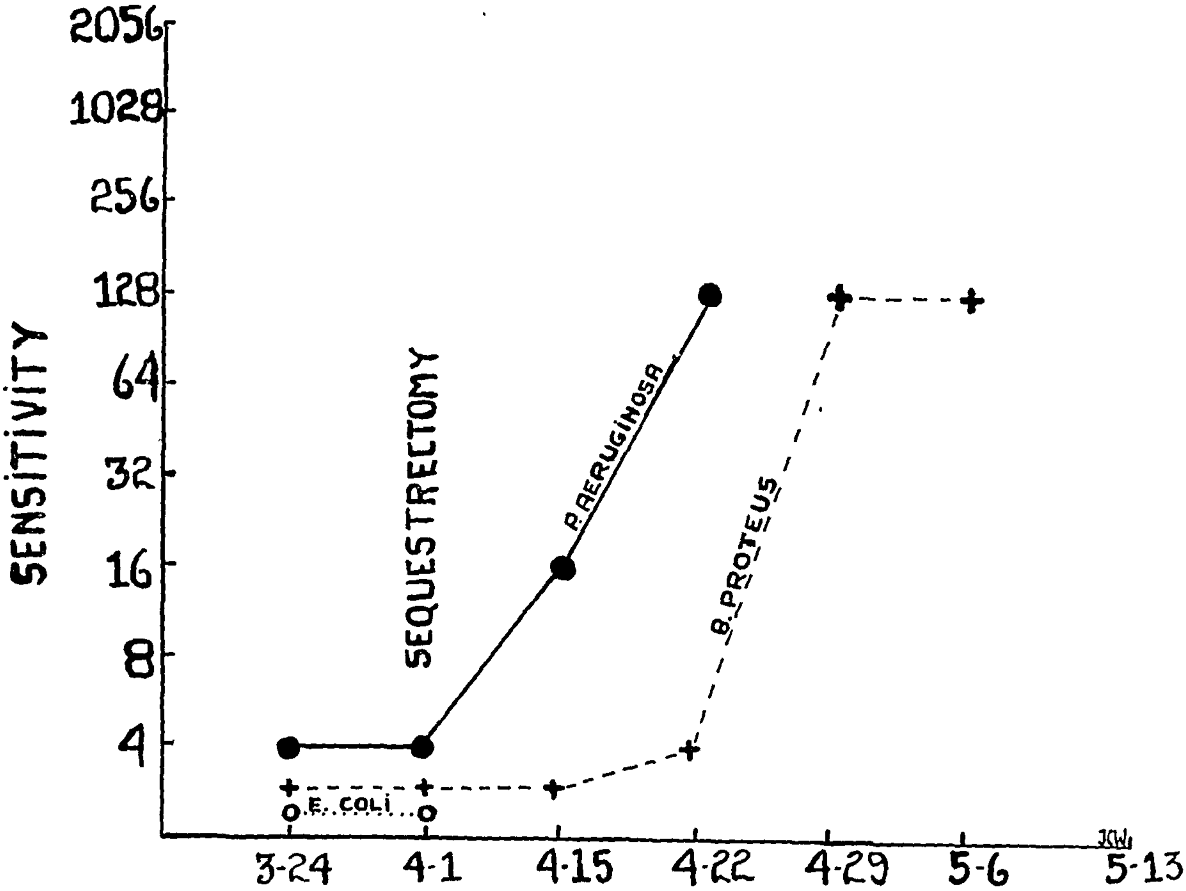

CHART II

Escherichia coli disappeared after sequestrectomy. *Bacillus proteus* and *Pseudomonas aeruginosa* persiste and rapidly developed resistance to streptomycin.

low values were found, the patient was placed upon a high-protein diet; and infusions c plasma and amigen were administered.

Twenty-four hours before surgery, the intramuscular injection of streptomycin wa commenced. If the organisms were sensitive to 16 micrograms of streptomycin or less pe cubic centimeter of media, the drug was administered in the dose of 0.5 gram every fou hours for a total of 3 grams per day. With this amount of drug the blood level average 16 micrograms per cubic centimeter of serum. Although levels of 32 micrograms wer found during the first hour after injection, this value became stabilized at about 16 micro grams and dropped rapidly during the fourth hour. A ten-day course was prescribed; th total drug given equaled 30 grams. The author of this paper is in full agreement wit Pulaski, Sprinz, Heist, and Ehrhorn, who have found that dosages in excess of 3 gram per day provide no additional benefit, regardless of the type and severity of the infection Furthermore, the percentage of toxicity is roughly proportionate to the amount of drug given. The course of streptomycin by injection has been limited to ten days for two reasons: The prolongation of therapy with this dosage leads to more toxic reactions; and the bacteria develop a resistance to the drug with such amazing rapidity that blood levels which can be obtained are no longer bacteriostatic. Examples of this phenomenon are shown in Chart I and Chart II.

The solution for the parenteral administration of streptomycin consists of one gram of drug, eight cubic centimeters of sterile normal saline, and two cubic centimeters o 1 per cent. procaine solution. In this preparation, one cubic centimeter of solution contains 0.1 gram of streptomycin. The procaine is added to diminish the discomfort of intramuscular injection.

For local use, a mixture of streptomycin and dry, powdered plasma was prepared. With sterile precautions, 16 grams of streptomycin was mixed with approximately 120

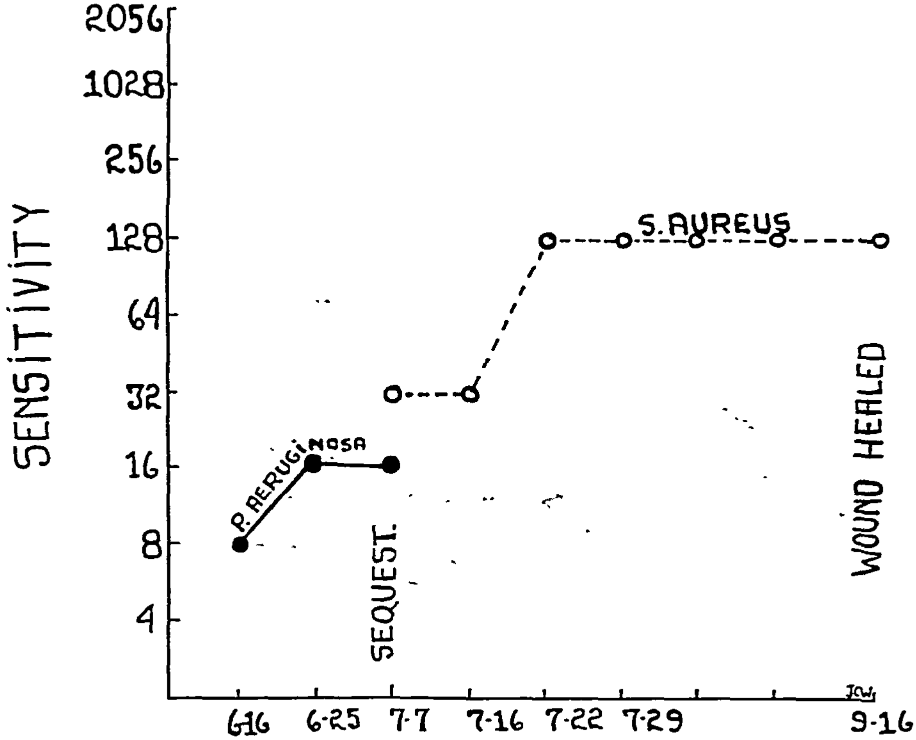

CHART III

Pseudomonas aeruginosa disappeared after sequestrectomy had been performed and streptomycin administered. *Staphylococcus aureus* appeared in culture after surgery. Penicillin was administered, as well as streptomycin.

grams of dry, powdered, human plasma. After thorough mixing, the preparation was divided equally into thirty-two bottles, so that each bottle contained approximately 0.5 gram of streptomycin and 4 grams of plasma. The bottles were sealed with paraffin and stored under refrigeration until used. Plasma was chosen as a medium for carrying the streptomycin, because of its buffering action. The drug is effective only in an alkaline medium. Plasma aids in maintaining the wound pH at a value nearer that which is optimum for the action of streptomycin. Furthermore, the hemostatic agents present in plasma are helpful in controlling ooze from wound surfaces.

In addition to streptomycin, penicillin has been given intramuscularly in doses varying from 50,000 to 100,000 units every three or four hours, depending upon the severity and the sensitivity of the infection caused by gram-positive organisms. Frequently, this drug was not given until sensitive organisms had appeared in the culture. These appeared often after streptomycin had controlled large numbers of gram-negative bacteria. Unless toxicity developed, penicillin was continued until the wound had healed (Chart III).

Without doubt, sequestrectomy is the most important single part of treatment. Unless all necrotic bone has been removed, no amount of streptomycin or other agent will heal these wounds. The technique of sequestrectomy has varied in certain respects. The object of surgery, of course, has been the thorough and complete removal of all dead bone and devitalized soft tissue, and saucerization of the wound so that no overhanging ledges of bone remain. In the majority of these patients, the bone was approached by excision of the sinus tract. The soft parts were reflected from the old fracture site, and a sequestrectomy was performed. However, when the sequestra lay in portions of the bone anatomically inaccessible from the entrance of the discharging sinus, we did not hesitate to approach the bone through clean tissue. These wounds were closed primarily by the use of deep skin sutures of stainless-steel wire, without subcutaneous closure. The sinus itself

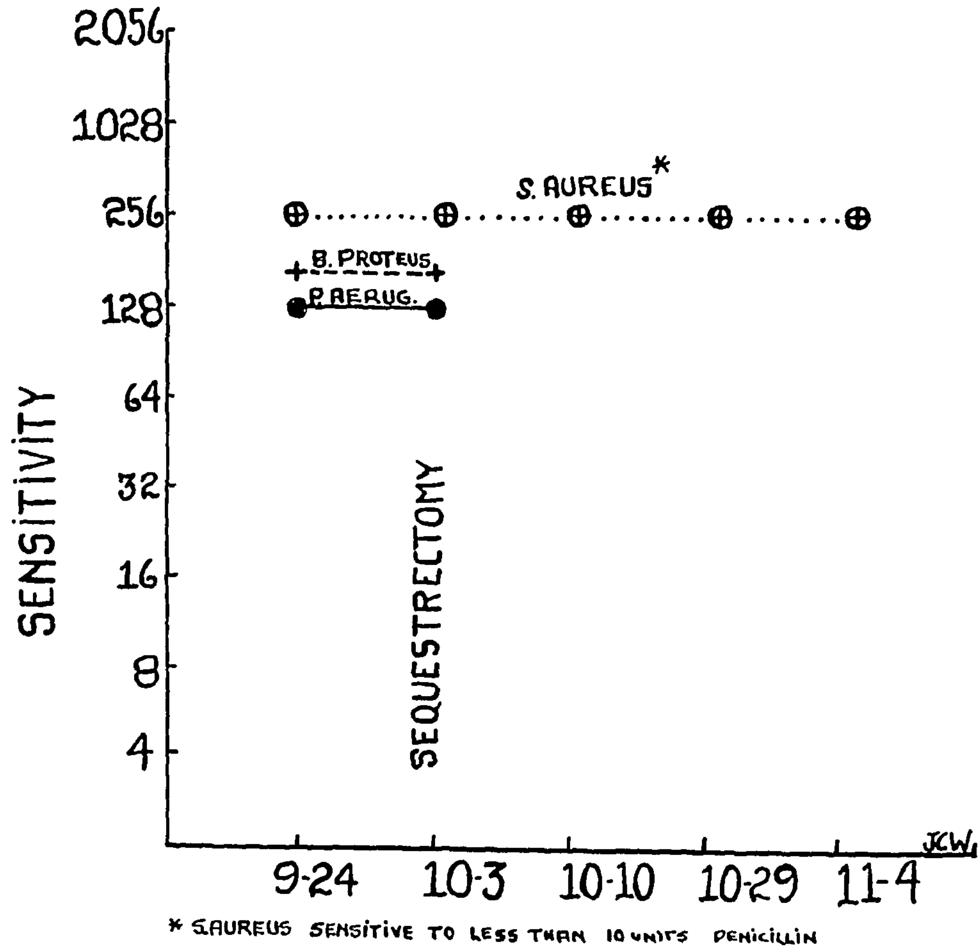

CHART IV

Despite the resistance of *Bacillus proteus* and *Pseudomonas aeruginosa* to streptomycin, they disappeared from culture after sequestrectomy and the use of local streptomycin.

FIG. 1-A

Case 13. Anteroposterior and lateral views of the femur, taken May 19, 1945, a week after injury.

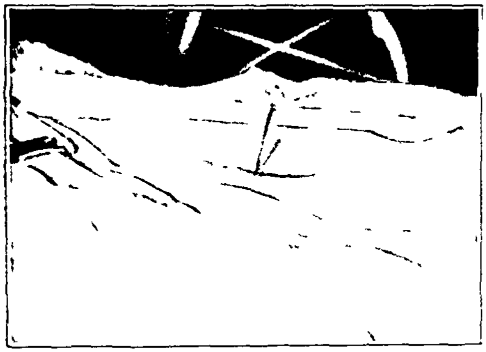

FIG. 1-B

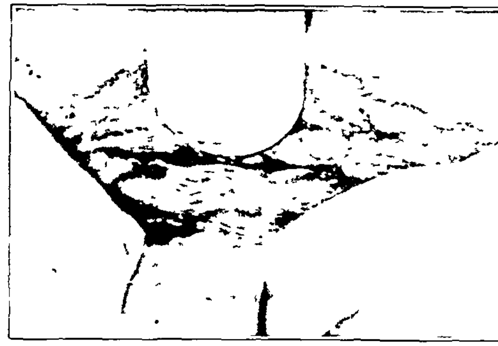

FIG 1-C

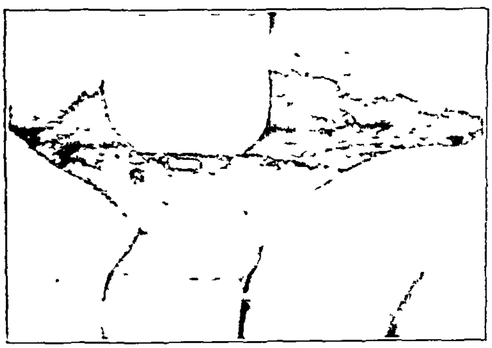

FIG. 1-D

FIG. 1-E

FIG. 1-F

FIG. 1-G

FIG. 1-H

Fig. 1-B: Photograph of wound, draped for sequestrectomy. Probe has been inserted into sinus tract.

Fig. 1-C: The femur is exposed; the sequestrectomy has been completed.

Fig. 1-D: The streptomycin-plasma mixture has been dusted into the wound.

Fig. 1-E: The glass-cloth pack is in place.

Fig. 1-F: Appearance of wound two weeks after sequestrectomy.

Fig. 1-G: Four weeks after sequestrectomy.

Fig. 1-H: Eight weeks after sequestrectomy.

was then enlarged sufficiently to permit dressing and drainage. This procedure violates a cardinal principle of the treatment of infection, but no undue complication resulted from such an approach.

While the bone was being exposed, no more periosteum was reflected than was abso-

lutely necessary. Sclerotic bone was drilled, to permit the entrance of granulations. An effort was made to re-establish marrow cavities, when they had become obliterated.

A tourniquet was employed, when feasible, to limit blood loss. Large amounts of scar tissue were excised; and, when possible, the wound margins were debrided until grossly uninfected tissue remained.

The wound was irrigated with one or two liters of normal saline which had been warmed to body temperature. Hemostasis was obtained by electrocautery, by pressure, and with fine catgut ties. No more foreign suture material was introduced into a wound than was needed for the control of large vessels. Silk and cotton were avoided assiduously.

Following irrigation, 200,000 units of penicillin in five cubic centimeters of normal saline was poured into the wound. The streptomycin-plasma mixture was then dusted over the wound surfaces. In small wounds, 0.5 gram of streptomycin was adequate; but in larger wounds, 1 or 1.5 grams were used.

The wound was then lined with glass cloth. This material has been chosen as a wound dressing, because its fine mesh prevents granulations from growing into the substance of the dressing. Glass cloth is not irritating; it keeps wound surfaces smooth, and prevents the growth of ragged, hyperabundant granulations. At the time of dressing the cloth can be lifted from the wound with ease, and with a minimal amount of discomfort to the patient.

The glass cloth was packed loosely with dry gauze, and a voluminous dressing was applied. If bony union was tenuous or absent, the part was enclosed in plaster-of-Paris; otherwise no plaster was used. The extremity was dressed with gauze, sheet wadding, and elastic bandages.

During the operation a transfusion of 500 cubic centimeters of whole blood was given. The patient's hemoglobin was determined on the first or second postoperative day and, if below 80 per cent., a second transfusion was given.

Fig. 1-I Fig. 1-J

Fig. 1-I: Anteroposterior view of the femur, taken May 26, 1947, prior to sequestrectomy.
Fig. 1-J: Anteroposterior and lateral views of the femur, taken August 1, 1947, after healing of wound.

The immediate postoperative care has been routine. An adequate fluid intake was maintained by intravenous fluids for the first and second days. A liquid diet was increased to a full diet as the clinical condition of the patient improved.

The wounds were not disturbed for fourteen days. At the end of the second week the patient was taken to the operating room, where, under strict aseptic technique, the wound was inspected. If bony union was absent, the dressing was carried out through a window in the plaster, so that the healing process in the bone might not be disturbed unnecessarily. The glass cloth was lifted gently from the wound, and a culture was taken. The wound was flushed with saline. A layer of fibrin often covered the granulations. This was removed from the underlying tissue with forceps. Its removal is advocated, so that the antibiotic drugs can be in more intimate contact with the healing surfaces. Streptomycin in plasma, and penicillin, were then added, and the wound was again dressed with glass cloth.

The first dressing has occasionally been accompanied by mild discomfort. Thereafter, the patients have experienced no pain whatsoever. In over one hundred dressings, an anaesthetic was given in only one instance. Dressings were done at weekly intervals in the operating room, until the wound had healed or until such a small patch of granulations remained that careful dressing on the ward would not endanger the final healing (Figs. 1-A to 1-J).

The local use of streptomycin should be continued until the wound heals, for although gram-negative bacteria may disappear early from culture, the premature withdrawal of the drug will result in their reappearance. Despite the fact that some organisms have been insensitive to 32, 64, or 128 micrograms of the drug, we have found that these organisms disappear from culture with the local use of streptomycin. When these low sensitivities are encountered, the local drug alone should be used. Blood levels obtainable with the systemic injections are of no avail. The disappearance of organisms from culture is sufficient indication for the use of streptomycin locally, regardless of the sensitivity (Chart IV).

In the majority of these cases an average of six dressings were done in the operating room. Thereafter, the patients were kept in bed until all signs of reaction, such as erythema and increased skin temperature, had subsided from the wound. The time period for healing has been about eighty days. There was very little difference in the healing time of those patients receiving local treatment and those treated with both local and systemic streptomycin. The use of the drug systemically is an added protection, should bacteria be introduced into the blood stream at the time of operation.

The use of parenteral streptomycin has been accompanied by some toxic reactions. All of the patients complained of peri-oral anaesthesia. The cause of this symptom is not known, but it was considered to be of no major importance clinically.

In one patient a maculopapular eruption developed over the back and chest at the completion of a course of 30 grams. The erythematous rash subsided spontaneously within forty-eight hours after administration of the drug had been discontinued.

The toxic signs of great importance are related to involvement of the auditory and vestibular branches of the eighth cranial nerve, either by the drug itself or by some impurity in it. Four patients complained of severe vertigo, and two of these had associated deep pain in both ears. One patient became dizzy after 7.5 grams of drug had been given. Another became dizzy after the administration of 2 grams. In two of the four, vertigo developed after the completion of the course of 30 grams. One of these patients complained of vertigo for six weeks (Case 15) and the other for eight weeks (Case 8). These two patients were seen by consultants of the Ear, Nose, and Throat Section on two occasions, but no permanent defect in the labyrinthine apparatus could be detected. Both patients recovered spontaneously from their vertigo and have had no further difficulty. No cases of deafness have been encountered in this series. The appearance of eighth-nerve symptoms demands the immediate cessation of parenteral administration of streptomycin. However,

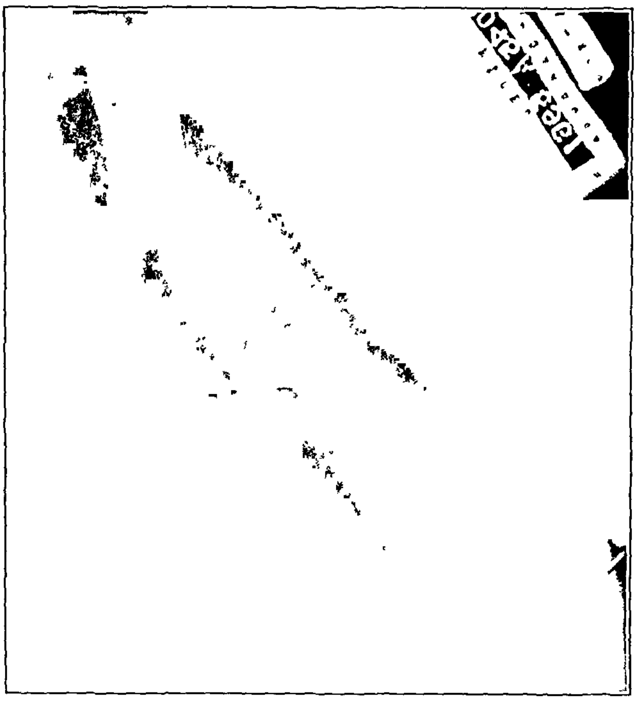

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case 14. Anteroposterior view of the humerus. Roentgenogram taken August 10, 1945, three weeks after injury.

Fig. 2-B: Anteroposterior and lateral views of the humerus in May 1947, prior to discharge from the hospital. The bone strength is far below normal. The patient was given a brace to wear for protection. At a later date he may need further reinforcement.

the appearance of toxic symptoms does not offer any contra-indication to the continued use of streptomycin locally. Frequent blood levels, determined in patients on local therapy alone, have failed to reveal the absorption of any demonstrable amount of drug from the wound itself.

The results of treatment in this series of patients have been very encouraging (Figs. 2-A and 2-B). Of the twenty-five cases, healing occurred in twenty-one. Four failed to respond, and all of these have had amputations. One patient's infection has been healed for eleven months, after persistent drainage for thirty-three months. In several, healing has been present for seven months; in others, for two, three, four, and five months at the time of writing. The patients have been universally enthusiastic, because their wounds have been almost painless and odorless, and their dressings have caused minimal discomfort.

CASE REPORTS

CASE 1. A white male, aged thirty-nine, was wounded in action on October 19, 1944, and sustained a compound, comminuted fracture of the proximal third of the left tibia and fibula. A diagnosis of osteomyelitis was made in February 1945. Between June 1945 and November 1946, the patient had six sequestrectomies, but drainage persisted. On February 26, 1947, a sequestrectomy was performed and the administration of streptomycin was commenced. The wound had entirely healed by June 2, 1947. (Local streptomycin only.)

CASE 2. A white male, aged twenty-nine, was wounded in action on May 21, 1945, and sustained a compound, comminuted fracture of the middle third of the right femur with laceration of the sciatic nerve. A diagnosis of osteomyelitis was made on June 11. Drainage was continuous from June 1945 until December 1946, during which time five sequestrectomies were performed. Sequestrectomy with the administration of streptomycin was carried out on December 19, 1946. The wound had healed by March 1, 1947. (Local and systemic streptomycin.)

CASE 3. A white male, aged twenty-three, was wounded in action on December 12, 1944, and sustained a penetrating wound of the abdomen, a compound fracture of the right iliac crest, and a bladder wound. These healed satisfactorily. In November 1945, while under treatment after removal of a foreign body from the buttock, hematogenous osteomyelitis developed in the right femur. The wound drained continuously from

December 1945 until December 1946, during which time three sequestrectomies were performed. On December 28, 1946, another sequestrectomy was performed and the administration of streptomycin was commenced. The wound had healed by March 24, 1947. (Local and systemic streptomycin.)

CASE 4. A white male, aged nineteen, was struck by a falling tree during a typhoon on Guam, September 21, 1946, and sustained a compound, comminuted fracture of the distal third of the left humerus. Open reduction with plating was done the same day as the injury; the operative wound became infected. The plate was removed October 26, 1946, but drainage persisted. Sequestrectomy was performed on January 21, 1947, and streptomycin was given. The wound had healed by March 19, 1947. (Local and systemic streptomycin. Vertigo appeared after 7.5 grams of the drug had been given systemically.)

CASE 5. A white male, aged twenty-six, was wounded in action on February 25, 1945. He sustained a compound, comminuted fracture of the middle third of the right femur, and traumatic amputation of both feet. Osteomyelitis in the femur was diagnosed in May 1945. The wound drained continuously from February 1945 until January 1947, during which time three sequestrectomies were performed. On January 21, 1947, sequestrectomy was carried out with administration of streptomycin. The wound had healed entirely by April 21, 1947. (Local and systemic streptomycin. Vertigo and pain in both ears after 2 grams of systemic drug.)

CASE 6. A white male, aged twenty-seven, was wounded in action on February 19, 1945, and sustained compound, comminuted fractures of the right tibia and fibula, the left tibia and fibula, and the left femur. Osteomyelitis in the left femur was diagnosed in February 1945. Drainage was continuous from February 1945 to March 1947, during which time three sequestrectomies were performed. Another sequestrectomy was done, with administration of streptomycin, on March 26, 1947. The wound had healed entirely by June 5, 1947. (Local and systemic streptomycin.)

CASE 7. A white male, aged twenty-eight, was wounded in action on April 17, 1945, and sustained a compound, comminuted fracture of the middle third of the right tibia. Osteomyelitis was diagnosed in May 1945. Intermittent drainage persisted from April 1945 to April 1947, during which time two sequestrectomies were performed. The first was done one year prior to a bone graft, and the second six months after the graft, which had become infected. On April 16, sequestrectomy was done, with administration of streptomycin. The wound had healed by June 2, 1947. (Local and systemic streptomycin.)

CASE 8. A white male, aged thirty-three, was wounded in action on November 22, 1944, and sustained a compound, comminuted fracture of the mid-shaft of the left femur. The fracture resulted in non-union. On March 27, 1945, a dual onlay bone graft was placed upon the femur. The operative wound became infected. Between August 31, 1945, and January 1947, six sequestrectomies were performed, but drainage persisted. On April 4, 1947, sequestrectomy was performed and the administration of streptomycin was commenced. The wound had healed entirely by June 2, 1947; it remained healed for five months, and then drainage recurred. The result in this case was a failure, and the extremity was amputated in November 1947. (Local and systemic streptomycin. Vertigo began after the course of systemic drug had been completed; the vertigo persisted for eight weeks.)

CASE 9. A white male, aged thirty-two, was wounded in action on November 24, 1944, and sustained a compound, comminuted fracture in the mid-shaft of the left femur. Osteomyelitis was diagnosed four weeks after injury. Between May 1945 and January 1947, nine sequestrectomies were performed. On February 6, 1947, sequestrectomy was done, with administration of streptomycin. The wound was dry for four days, beginning on June 7, 1947, and then drainage recurred. Another sequestrectomy, with local administration of streptomycin, was done on August 6. For one week, beginning September 28, there was no drainage. Amputation of the extremity was done in October 1947. The result was a failure. (Local and systemic streptomycin. A maculopapular erythematous rash appeared during systemic administration.)

CASE 10. A white male, aged twenty-seven, was wounded in action on January 11, 1945, and sustained a compound, comminuted fracture of the proximal and distal thirds of the left tibia and fibula, and traumatic amputation of the right lower extremity above the knee. Sequestrectomy in the left tibia was done in February 1945. On May 13, 1946, bone chips were placed in the defect in the left tibia, followed by infection of the wound. On March 5, 1947, sequestrectomy was done, and administration of streptomycin was begun. The wound had healed by June 6, 1947. (Local streptomycin.)

CASE 11. A white male, aged thirty-three, was injured in the crash of a B-25 on January 29, 1946. He sustained compound, comminuted fractures of the right tibia and fibula at the ankle, with lateral dislocation of the foot and extensive soft-tissue damage. An open reduction was attempted the day of injury, but was unsuccessful. A successful reduction was done on February 13, 1946. Following this procedure the sepsis in

the fracture became apparent. On March 24, 1947, astragalectomy and resection of the lateral malleolus were done, with local administration of streptomycin. The wound did not heal, and a below-the-knee amputation, guillotine type, was done on July 16, 1947. The result in this case was a failure. (Local streptomycin.)

CASE 12. A white male, aged twenty-eight, was wounded in action on February 2, 1944, and sustained a compound, comminuted fracture of the distal third of the left femur, involving the knee joint. On March 20, a diagnosis of osteomyelitis was made. Sequestrectomies were performed in September 1944, November 1945, December 1946, and March 1947. A sequestrectomy was done in April 1947, with administration of streptomycin. There was no response to therapy, and a guillotine amputation was done above the left knee on July 15, 1947. The result in this case was a failure. (Local and systemic streptomycin.)

CASE 13. A white male, aged thirty-one, was wounded in action on April 12, 1945; he sustained a traumatic amputation above the right knee, and a compound, comminuted fracture in the mid-shaft of the left femur, with sciatic palsy. Osteomyelitis of the left femur was diagnosed in June 1945. Sequestrectomies were done in August 1945, February and September 1946, and February 1947, but drainage persisted. A sequestrectomy with application of streptomycin was done on June 4, 1947. The wound had healed completely by August 9, 1947. (Local streptomycin.)

CASE 14. A white male, aged twenty-one, was wounded in action on July 20, 1945, and sustained a compound, comminuted fracture of the mid-shaft of the right humerus. The first sequestrectomy was done on December 10. On August 29, 1946, an onlay bone graft was applied to the right humerus, followed by infection in the wound. On February 19, 1947, a sequestrectomy was done, with administration of streptomycin. The wound had healed entirely by April 16, 1947. (Local and systemic streptomycin.)

CASE 15. A white male, aged twenty, was wounded in action on January 4, 1945, and sustained a compound, comminuted fracture of the distal third of the right femur. Although drainage had been present since June 1945, the first sequestrectomy was done on January 28, 1946. Sequestrectomies were done on May 24, 1946, and February 3, 1947. A sequestrectomy with administration of streptomycin was carried out on April 1, 1947. The wound had healed by August 21, 1947. (Local and systemic streptomycin, with onset of vertigo after completion of the systemic drug. The vertigo persisted for six weeks.)

CASE 16. A white male, aged thirty-three, was wounded in action on March 25, 1945, and sustained compound, comminuted fractures of both bones of the right forearm; a compound, comminuted fracture of the distal third of the left femur; and a compound, comminuted fracture involving the head and neck of the right femur and the right acetabulum. Saucerization of the right hip and sequestrectomy of the head of the femur were done on October 11, 1945. Drainage persisted, despite two attempts at closure of the defect. Sequestrectomy was performed on May 29, 1947, with administration of streptomycin. The wound had healed by August 12, 1947. (Local streptomycin.)

CASE 17. A white male, aged thirty, was wounded in action on November 4, 1944, and sustained a compound, comminuted fracture of the proximal third of the right tibia and fibula and the proximal third of the right femur. The wound in the femur healed without complication. In February 1945, osteomyelitis in the tibia was diagnosed. Continuous drainage occurred from February 1945 to March 1947, despite several sequestrectomies and attempted closure of the defect in bone by the use of an acrylic implant. On March 5, 1947, a sequestrectomy was done, with administration of streptomycin. The wound had healed entirely by August 14, 1947. (Local and systemic streptomycin.)

CASE 18. A white male, aged twenty-five, was wounded in action on March 25, 1945, and sustained a compound, comminuted fracture of the distal third of the left femur. A diagnosis of osteomyelitis was made a few weeks after the injury. Sequestrectomies were done in April, May, June, and July 1945, and in July 1946. The wound remained healed from January to June 1947. Drainage recurred on June 13. Sequestrectomy was done on July 7, with administration of streptomycin. The wound had healed by September 16, 1947. (Local and systemic streptomycin.)

CASE 19. A white male, aged twenty-two, was wounded in action on December 25, 1944. He sustained a compound, comminuted fracture of the distal third of the right tibia and fibula. Sequestrectomies were done in May, June, and August 1945. The wound was dry until October 1946, when drainage recurred. Sequestrectomy was done on June 24, 1947, with administration of streptomycin. The wound had healed by September 3, 1947. (Local streptomycin.)

CASE 20. A white male, aged twenty-one, was wounded in action on March 28, 1945, and sustained a compound, comminuted fracture of the distal third of the right femur, with involvement of the knee joint. Osteomyelitis was present within a few weeks of the injury. Sequestrectomies were performed in January and

October 1946, but drainage persisted for a total of twenty-nine months. Sequestrectomy was done on August 11, 1947, with administration of streptomycin. The wound had healed entirely by September 24, 1947. (Local streptomycin.)

CASE 21. A white male, aged thirty-three, was wounded in action on December 5, 1944, and sustained a compound, comminuted fracture of the distal third of the left tibia. The wound had healed within a few weeks after the injury, but the fracture went on to non-union. A bone graft was performed in November 1945; the operative wound became septic and drained for twenty-one months. Sequestrectomy was done on August 19, 1947, with administration of streptomycin. The wound had healed by October 19, 1947. (Local streptomycin.)

CASE 22. A white male, aged twenty-six, was wounded in action on April 19, 1945, and sustained a compound, comminuted fracture of the mid-third of the right tibia. Drainage continued from the time of injury until October 1947, despite seven sequestrectomies. A sequestrectomy was done on October 3, 1947, with administration of streptomycin. The wound had healed by December 7, 1947. (Local streptomycin.)

CASE 23. A white male, aged thirty, was wounded in action on February 9, 1945. He sustained a compound, comminuted fracture through the left sacro-iliac joint, with fragmentation of the sacrum and ilium. The wound healed soon after injury, but broke down and drained in August 1945. Numerous sequestrectomies, secondary closures, and applications of split-thickness grafts were carried out between August 1945 and July 1947. On July 25, 1947, sequestrectomy was done, with administration of streptomycin. The wound had healed entirely by November 12, 1947. (Local streptomycin.)

CASE 24. A white male, aged twenty-four, was wounded in action on January 8, 1944, and sustained a compound, comminuted fracture of the right femur with traumatic avulsion of the patella. Profuse drainage occurred after injury. A sequestrectomy was done in March 1945. On July 26, iliac chips were placed in the defects about the knee joint, but the operation was followed by sepsis. Sequestrectomies were done in November 1946 and on June 11, 1947. Another sequestrectomy, with administration of streptomycin, was carried out on September 26, 1947. The wound had healed by November 17, 1947. (Local streptomycin.)

CASE 25. A white male, aged thirty-three, was wounded in action on October 2, 1944. He sustained multiple injuries of both hands and compound, comminuted fractures of the right radius and ulna. Sequestrectomies of the right radius were done in February 1945, April 1946, and September 1947. On October 24 another sequestrectomy was done, with administration of streptomycin. The wound had healed by November 17, 1947. (Local streptomycin.)

SUMMARY AND CONCLUSIONS

Twenty-five cases of chronic osteomyelitis are presented, in which discharging sinuses had been present for an average of nineteen months. Many types of treatment had been tried, without success. In an effort to promote healing, a plan of therapy was evolved upon the following principles:

1. Thorough investigation of the wound bacteria;
2. Radical sequestrectomy after adequate preoperative preparation;
3. The use of streptomycin and penicillin before, during, and after surgery;
4. Meticulous wound care after surgery to prevent contamination.

Twenty-one patients have responded very favorably to this regimen, and their wounds have healed. Four patients failed to respond; and all have had amputations.

The author wishes to emphasize strongly that the use of streptomycin offers no panacea for the treatment of chronic osteomyelitis. The drug is not a replacement for adequate surgery; but, when combined with thorough sequestrectomy, it is beneficial in the promotion of healing.

No statement is made with regard to recurrence of drainage in these patients. No claim is made that the course of the disease has been altered permanently or that a cure has been obtained in any case. However, the salutary response of the patients to this treatment, which allowed their prompt return to a healthy, useful life, has persuaded the author to present this study as a preliminary report.

NOTE: The author wishes to express his sincere appreciation to Colonel Carl Rylander, Medical Corps, United States Army, for his continued encouragement throughout the study and for his generosity in providing the facilities so that the work might be carried on.

Acknowledgment is also made to Lieutenant Melvin Frieswyk, Medical Corps, Army of the United States, for his valuable assistance in the compilation of the bacteriological data, and for his meticulous preparation of the streptomycin-plasma mixtures.

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DIFFUSE INFLAMMATION OF CARTILAGE

A CASE REPORT OF A HITHERTO UNREPORTED ENTITY

BY EVERETT J. GORDON, M.D., WASHINGTON, D. C., AARON W. PERLMAN, M.D., CINCINNATI, OHIO, AND NATHAN SHECHTER, M.D., ROCK ISLAND, ILLINOIS

From the Orthopaedic Surgery Division of the Department of Surgery, University of Cincinnati*

The case to be reported here presented a bizarre clinical course and widespread inflammation and degeneration of arthrodial and non-arthrodial cartilage. Neither the clinical features nor the histopathology conformed to any recognized disease entity, and the condition has defied classification by orthopaedic surgeons, otolaryngologists, internists, and pathologists. The microscopic sections ** have been widely distributed for study, but to date no definite diagnosis has been forthcoming. The term "Diffuse Inflammation of Cartilage" has been adopted for identification purposes only.

CASE REPORT

M. W. (No. 200683), a negress, thirty-four years old, first came under observation in July 1944, in the Receiving Ward, because of cough and dyspnoea. No conclusive diagnosis was made. She did not return for further treatment until September, although the cough had persisted and the dyspnoea had become more severe. The cough was productive at first of small amounts of whitish sputum, which later became yellowish and purulent. The dyspnoea was chiefly the result of exertion. A roentgenogram of the chest failed to show any evidence of tuberculosis. In November, she first noticed swelling and tenderness in both knees and ankles, followed by repeated remissions and exacerbations, especially in the left leg. During the second week of February 1945, an exacerbation of the pain and swelling of the left knee was accompanied by fever. On February 9, the left eye became swollen and painful. On February 11, she noted that both ears were swollen, tender, and boggy. She felt feverish, but had no chill. The cough, which had become steadily worse, was accompanied

* Service of Joseph A. Freiberg, M.D.

** On file at the Army Institute of Pathology (AIP Acc. 177038).

by hoarseness. The dyspnoea had progressively increased to a point where she was short of breath, even when at rest in bed. Because of increasing distress, she was admitted to the Hospital on February 14. Her chief complaints at this time were shortness of breath, pain in the chest, cough, and soreness of the left knee.

In her past history there was no record of exposure to tuberculosis, and no rheumatic fever. She denied having had gonorrhoea, syphilis, or any recent venereal exposure. Her only previous illness of consequence was a pelvic operation in 1929, of unknown type, for menstrual irregularity. She had had two pregnancies, one resulting in a miscarriage and the other in a child who was alive and well.

Physical examination revealed an acutely ill, febrile, apprehensive, irritable patient, lying restlessly in bed and complaining of marked substernal pain. She was markedly dyspnoeic; the respirations were thirty-two per minute. The temperature by mouth was 101.6 degrees. Both upper and lower lids of the left eye were swollen and oedematous, with hyperaemia and injection of the palpebral and bulbar conjunctivae. The fundi and pupils were normal. The auricles of both ears were boggy, soft, and tender, and contained nodular thickenings of the pinnae (Fig. 1); the canals and drums were normal. There was marked distention of the veins of the neck,

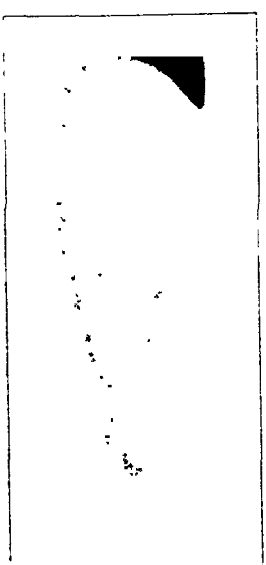


FIG. 1

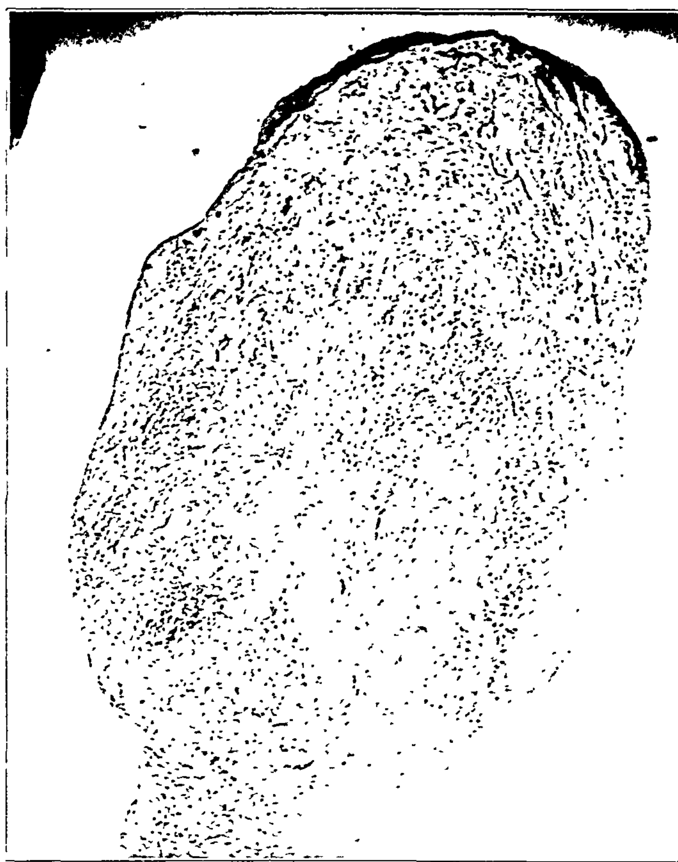


FIG. 2

Fig. 1: Roentgenogram of right ear, in February 1945, shows slight soft-tissue swelling.

Fig. 2: Photomicrograph (× 62) of biopsy specimen of ear (February 1945) shows areas of scarring, with oedema, shredding, and dense staining of some collagen bundles. Increased prominence of capillaries and cellular infiltration may be noted.

but the trachea was in the mid-line. Tenderness was noted over the entire larynx, as well as over the sternum and adjacent chest wall. Auscultation of the chest revealed harsh rhonchi, occasional expiratory wheezes in both lower lung lobes, and slightly impaired resonance over the right base. Except for marked sinus tachycardia with a rate of 130, the heart was normal. The blood pressure was 135 systolic and 85 diastolic. The abdomen had a healed scar from a gynecological operation, but otherwise was normal. There was definite tenderness over the spine from the second to the fourth thoracic vertebrae, but no accompanying deformity or muscle spasm. Moderate swelling of the left knee was noted, most of the swelling being medial and superior to the patella, with slight fluctuation and increase in local warmth. Passive flexion was possible only to 60 degrees, and was limited by pain. Both ankles were tender, but not swollen or increased in warmth. The inguinal, epitrochlear, and posterior cervical nodes were bilaterally enlarged, shotty, and non-tender. The reflexes were normal throughout. The remainder of the physical examination was negative. Reports of laboratory work done at this time were, unfortunately, lost. A diagnosis of diffuse chondritis, involving the cartilage

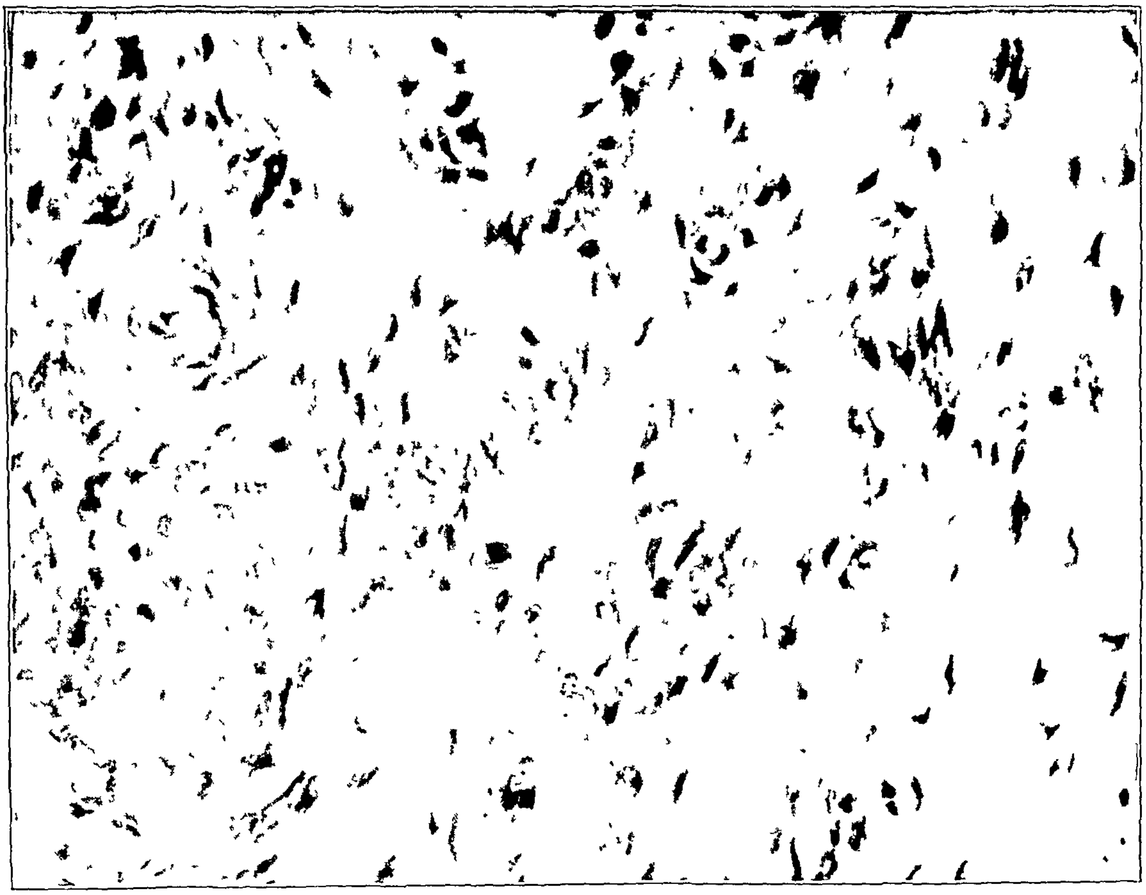


FIG. 3-B

FIG. 3-A

Fig. 3-A: Photomicrograph (×233) of biopsy specimen of trachea. Shows perivascular cuffing with polymorphonuclear and mononuclear cells. Dense collagen tissue is present.

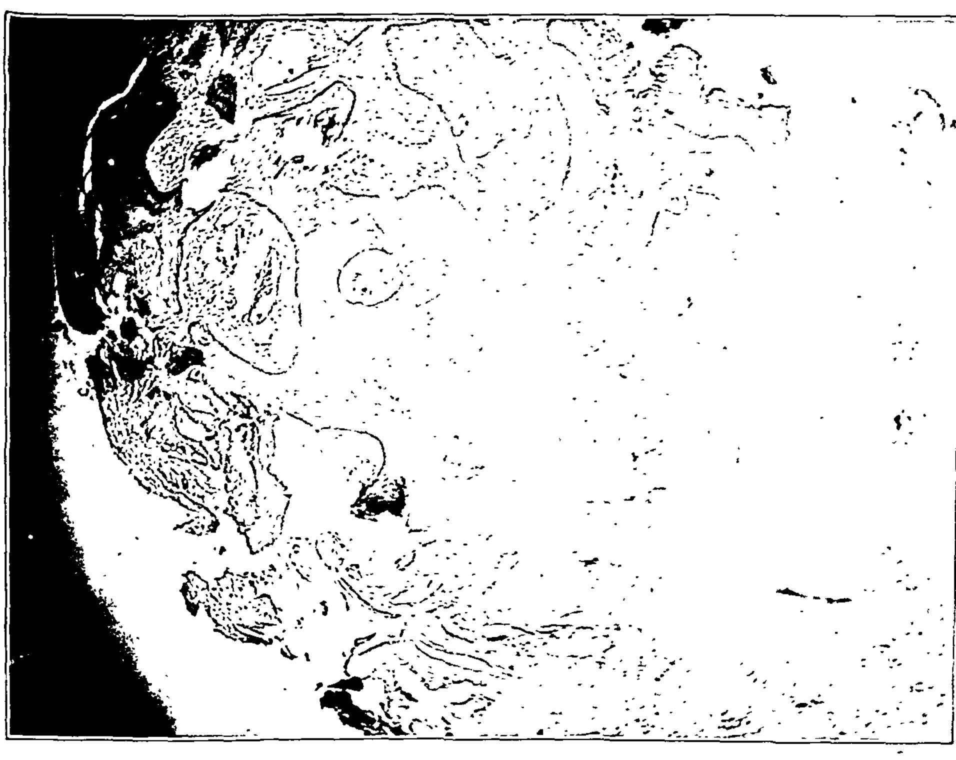


Fig. 4-A

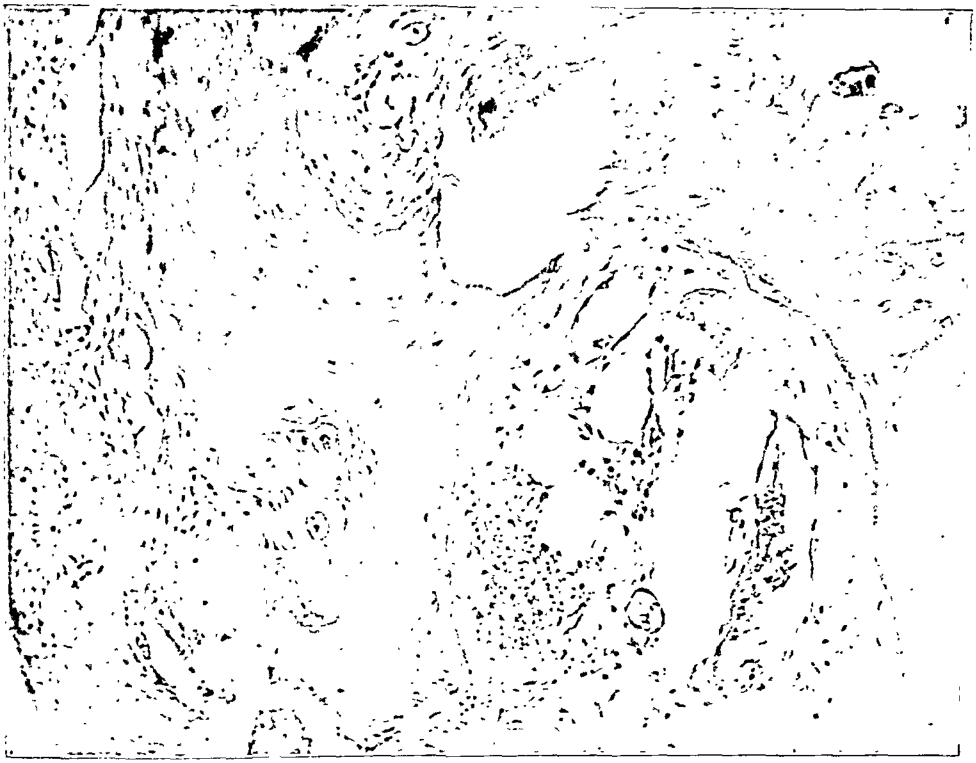


Fig. 4-B

Fig. 4-A: Low-power magnification (× 53) of ear specimen, taken in July 1946, shows dense collagen tissue, fibrocartilage, and well-formed bone trabeculae.
Fig. 4-B: Higher-power magnification (× 177) shows bone spicules with an outer capsule of fibrocartilage and periosteum-like connective tissue. Many osteoblasts and newly formed osteoid tissue may be seen. Plasma cells and vascular areolar tissue occur in the marrow spaces.

of the ears, nasal septum, and larynx, the costal cartilage, and possibly the joint cartilage of the left knee, was made by the medical consultant, Dr. Marion A. Blankenhorn.

Fluid was aspirated from the left knee joint and sulfamerazine therapy was instituted, adequate blood levels being maintained. However, laryngeal stridor developed with impending complete obstruction, and the otolaryngologist, Dr. Kurt Tschiassny, was called in consultation. Indirect laryngoscopy revealed marked anaemia of the arytenoids; slight reddening of the vocal cords, but with almost normal movement present; and almost complete closure of the subglottic space by an inward bulging of the mucous membrane, especially in the anterior circumference. It was believed that these findings did not represent the typical picture of a subglottic laryngitis, but probably indicated chondromalacia or perichondritis. On February 17, cartilage from the left auricle was taken for a diagnostic biopsy. On the following day, however, obstruction to the airway became so acute that a tracheotomy had to be performed under local anaesthesia; at this time a specimen of the third tracheal ring was also taken for biopsy examination. A number of laboratory investigations, performed at this time, were reported as follows:

1. The sputum was negative for tuberculosis.
2. Blood agglutinations were negative for Brucella, paratyphoid, typhoid, and dysentery.
3. A blood culture was negative.
4. A blood Kahn test was positive (two plus).
5. A culture of fluid aspirated from left knee joint was negative (no organisms).
6. A complement-fixation test for gonorrhoea was positive up to 0.05 cubic centimeter.
7. The blood chemistry showed: Uric acid 3.2 milligrams per 100 cubic centimeters.
   Urea nitrogen 9.4 milligrams per 100 cubic centimeters.

Roentgenographic studies of the chest, thoracic and lumbar spine, left ankle, hands, and ears were within normal limits. The left knee showed a slight excess of fluid within the joint. The biopsy studies of the left ear and trachea were reported as showing only evidence of chronic inflammation (Figs. 2, 3-A, 3-B, 4-A, and 4-B).

On March 1, 1945, the right elbow also became swollen and painful; the left knee and ankle were markedly improved. By March 7, the elbow was free from pain, but the knee and ankle had become more uncomfortable. On March 4, antisyphilitic therapy was begun; fifteen drops of potassium iodide three times a day, supplemented by intramuscular injections of bismuth in oil at weekly intervals, were given from March 24 to November 5, 1945.

On March 9, sulfonamide therapy was discontinued and penicillin, 15,000 units every three hours, was begun. This was continued until March 20, when a total of 1,320,000 units had been administered. The patient's general state improved and her temperature approached normal, one week after penicillin had been discontinued. During this time there were frequent periods of exacerbation and remission of the pain and swelling in the left knee.

On April 15, an electrocardiogram revealed myocardial damage. On May 4, another aspiration was done, and thirty cubic centimeters of moderately bloody fluid was obtained from the left knee; culture was still negative. Repeated aspiration, four days later, produced a thick, yellowish, semiclear fluid which clotted almost immediately to form a colorless jell. This fluid had a pH of 7.5 and a total cell count of 45,000 per cubic millimeter; it contained 5,400 white blood cells, of which 96 per cent. were polymorphonuclear and 4 per cent. were mononuclear. Gram's stain and acid-fast stains and culture were negative.

A second blood Kahn test, on May 11, was reported as one plus, and syphilis was then considered the etiology. A spinal puncture on May 15 gave negative findings, including the chemistry, cell count, Wassermann reaction, and colloidal-gold test.

Roentgenograms of the left knee and of both ankles at this time showed moderate patchy demineralization, persistent hydrarthrosis of the left knee joint, and narrowing of the joint spaces of both ankles, especially the left. Repeated roentgenograms of the left knee, several months later, disclosed partial destruction of the tibial spines, narrowing of the joint space, further patchy demineralization, and continued hydrarthrosis. There was a moderate valgus deformity. The hands still showed no roentgenographic changes.

The pain in the left knee became progressively worse, with an increasing flexion contracture. On October 1, adhesive traction was applied, overcoming most of the contracture, but this had to be discontinued after one month because of ankle oedema. Bilateral iritis and conjunctivitis developed at this time, but responded to conservative measures. However, recurrences were frequent during the patient's hospital stay, causing many periods of severe discomfort. A marked secondary type of anaemia developed, with a hemoglobin of 7.5 grams per 100 cubic centimeters and a white-blood-cell count of 7,700. Urinalysis revealed an occasional white blood cell, a pH of 5.5, and a specific gravity of 1.002.

The left knee again became painful and contracted after removal of the adhesive traction, but re-examination by roentgenogram revealed no significant changes. Wedging casts were applied on December 18, the deformity again yielding to the gradual forced extension.

Laboratory studies at this time showed an increase of hemoglobin to 9.5 grams; the white-blood-cell count was 8,500; and the sedimentation rate was 21 millimeters per hour. Urinalysis disclosed an occasional red blood cell but no white blood cells, a pH of 6.0, and a specific gravity of 1.002. Extension of the knee was progressively increased by the addition of turnbuckles to the cast, so that by April 1, 1946, the knee had been

extended to 155 degrees. At this time acute conjunctivitis arose accompanied by a temperature of 104.6 degrees: this infection responded to 600,000 units of penicillin. After removal of the cast there was still a good deal of local tenderness and swelling in the left knee and to lesser degrees, in both ankles. Further roentgenograms showed only an increase in the demineralization and narrowing of the joint space. A sleeve type of cast was applied to the left knee to maintain the corrected position, and the patient was discharged to the Out-Patient Service on June 7, 1946, walking on crutches. However, she could walk only a few feet because of the pain in both ankles, especially the left, in which there was restricted motion and mild equinus deformity, which had not responded to wedging casts. The tenderness and swelling of both ears and of the bridge of the nose were still present.

Six weeks later she was readmitted for further study and for a course of physiotherapy (diathermy and light stroking massage) to her left knee and ankle. The tracheotomy tube was functioning well, and she was well adjusted to its use and care. She was fairly comfortable except for the pain in her knee and ankle, which responded favorably to the physiotherapy. Physical examination revealed persistent swelling and tenderness of the pinnae of both ears and the bridge of the nose, which was also broadened and flattened. There was some swelling of the proximal interphalangeal joints of the third finger of each hand. Motion in the left knee was from 145 to 150 degrees, in the left ankle from 122 to 125 degrees, in the left foot, slight subtalar and mid-tarsal motion was possible, the left hip had normal motion. There was a normal range of motion in the right hip and knee, but marked restriction of subtalar and mid-tarsal motion in the right foot, with plantar flexion to 145 degrees and dorsiflexion to 115 degrees.

Laboratory studies made at this time were reported as follows:

Red blood cells	3,200,000
Hemoglobin	8 grams per 100 cubic centimeters
White blood cells	7,200
Differential count:	
Polymorphonuclear neutrophils	64 per cent.
Lymphocytes	34 per cent.
Monocytes	2 per cent.
Sedimentation rate (Cutler Method)	20 millimeters per hour
Blood chemistry:	
Calcium	11.1 milligrams per 100 cubic centimeters
Phosphorus	2.0 milligrams per 100 cubic centimeters
Phosphatase	4.6 Bodansky units
Urea nitrogen	8.2 milligrams per 100 cubic centimeters
Sugar	102 milligrams per 100 cubic centimeters
Creatinine	1.0 milligrams per 100 cubic centimeters
Uric acid	1.25 milligrams per 100 cubic centimeters
Urinalysis:	
pH	6.5
Specific gravity	1.018
Albumin	Trace
Sugar and acetone	0
White blood cells	0
Red blood cells	2 per high-power field

During this admission, specimens for biopsy studies were taken from the left ear (Figs. 4-A and 4-B), nasal septum, tenth left costal cartilage, and lateral epicondylar region of the left knee. The temperature remained normal except for a slight febrile response to the first biopsy, which rapidly subsided.

Roentgenograms disclosed no demonstrable changes in the right knee, but marked narrowing of the left knee joint with almost complete resorption of the cartilage and advanced demineralization (Figs. 5-A, 5-B, and 5-C). The ankles showed further narrowing of the joint space, marked demineralization of the tibia, fibula, and tarsi, and equinus position of both feet, the changes were more pronounced on the left (Fig. 6). There was no appreciable change in the lumbar spine. Both ears now contained multiple fragments of ossific material in the swollen, distorted soft tissues of both auricles (Figs. 7-A, 7-B, and 7-C).

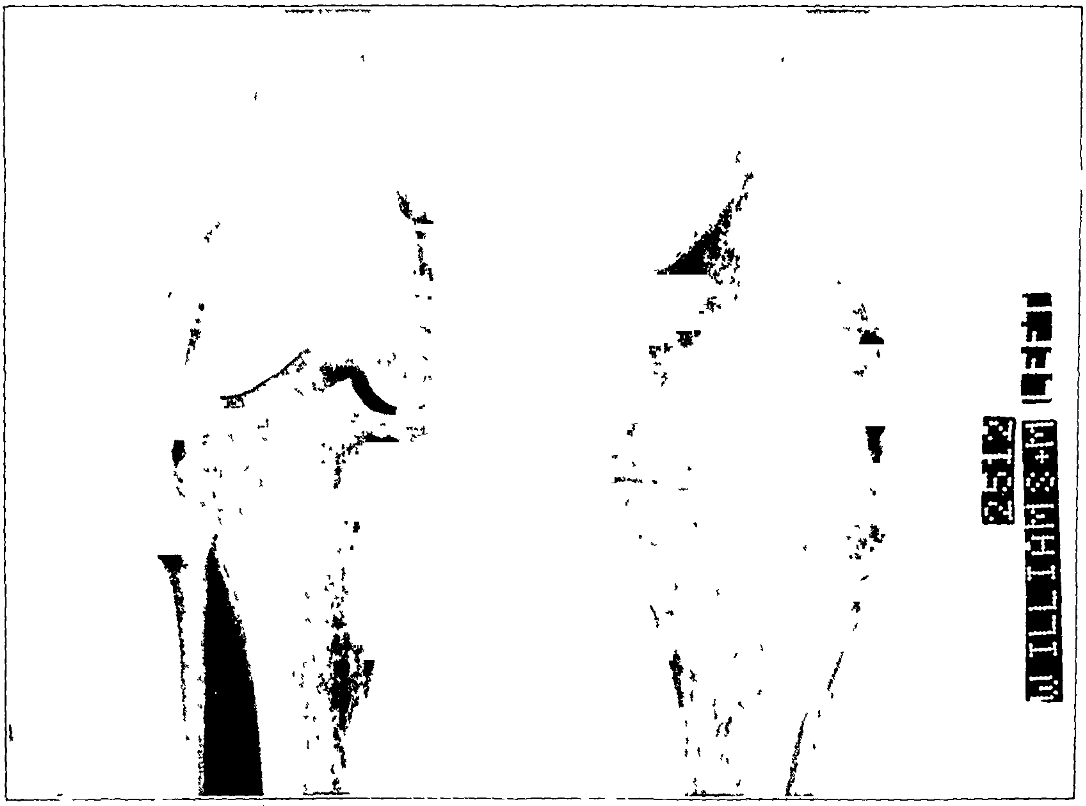
Anteroposterior views of the hands revealed destruction of the joint space of the proximal interphalangeal joint of the left middle finger, not present in the films taken one year previously. There was also slight erosion of the adjacent middle phalanx, associated with fusiform swelling of the soft tissues. Other joints of the fingers showed soft-tissue swelling, but no bone changes.

On August 19, she was again discharged to the Out-Patient Service as an ambulatory patient, able to walk only short distances on crutches. Another course of physiotherapy was instituted.

This patient was next seen on September 20, 1946, at which time the ears were greatly improved. The

left knee was extremely painful when motion was attempted, and was fixed at 135 degrees. There were only 2 to 3 degrees of motion in the left ankle, which was in 25 degrees of plantar flexion and slight varus. There was motion from 105 to 125 degrees in the right ankle. The blood Kahn test was again reported as one plus.

On October 1, she was readmitted for a period of two weeks for further study. The physical examination was essentially unchanged, and the temperature and pulse were normal. A complete blood count and sugar-tolerance curve were normal. The urine showed only 5 to 10 white blood cells per high-power field. The blood cholesterol was 250 milligrams per 100 cubic centimeters. She was given a heel lift for the left shoe because of the marked, fixed equinus, and was discharged.



Right Left

FIG. 5-A

Right Left

FIG. 5-B

July 1946. Right knee shows no demonstrable changes. Left knee shows marked narrowing of joint space, resorption of joint cartilage, and demineralization of all bones. Resorption of cartilage is more severe laterally, with resultant genu valgum.

On December 30, 1946, it was again necessary to admit the patient, as a result of acute tracheobronchitis, as well as acute conjunctivitis of the right eye. Both infections responded rapidly to sulfadiazine therapy, but hospitalization was necessary until April 3, 1947. Tracheobronchitis recurred two weeks later, and she was once more admitted to the Hospital for further sulfadiazine therapy. At this time it was noted that she had cataracts, complicating the old iridocyclitis of the right eye.

She was again seen in December 1947, at which time there had been no essential change in her condition. Because of extreme pain, occasioned by the slight amount of motion still present in the left knee, arthrodesis was performed in April 1948. The patient failed to respond after the operation, and died the next day. Permission for an autopsy was refused by the family.

HISTOPATHOLOGICAL FINDINGS

The detailed findings at microscopic examination are as follows:

I. *Rib* (Material taken from left tenth costal cartilage, July 1946)

Normal hyaline cartilage is seen, and normal cells in cartilage nests. In an occasional small focus, distinctness of cell-nest outlines is lost and there is some beginning increase in vascularity. No inflammatory processes and no destruction of tissue are seen.

II. *Knee*

1. Material taken from lateral femoral condyle of left knee, July 1946. No cartilage is present in the section. The marrow spaces are normal. The bone trabeculae are broad and well developed. There is an occasional trabecula, slightly broader than normal, with evidence of recent apposition of small amounts of osteoid tissue on the surface, associated with numerous osteoclasts. There is little or no evidence of osteoclastic activity. The Haversian canals are unusually wide for cortical bone.

2. Material taken from articular surface of lateral femoral condyle and from synovial membrane of lateral margin of joint space, December 1947.

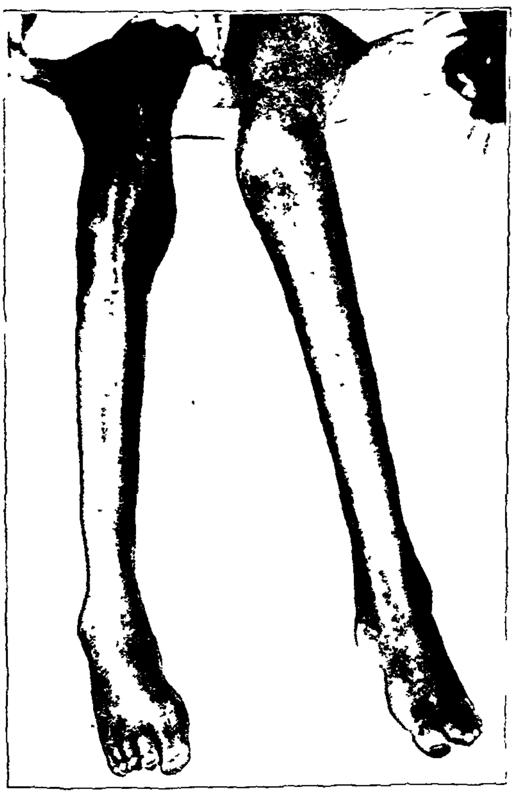


FIG. 5-C

FIG. 6

Fig. 5-C: Severe valgus of left knee is shown in this photograph, taken in August 1946. There is atrophy of both legs, more on the left. Fusiform swelling of left knee is evident, with patellar tendon not so distinct as on the right. The left ankle is markedly swollen, with pronounced equinus and slight varus of the foot. The right ankle is mildly swollen, in definite equinus, with varus of the foot and swelling of the metacarpophalangeal joint of the great toe.

Fig. 6: Roentgenogram of left ankle, taken in July 1946, shows narrowed joint space, marked demineralization of all bones, and equinus position of foot.

FIG. 7-A

FIG. 7-B

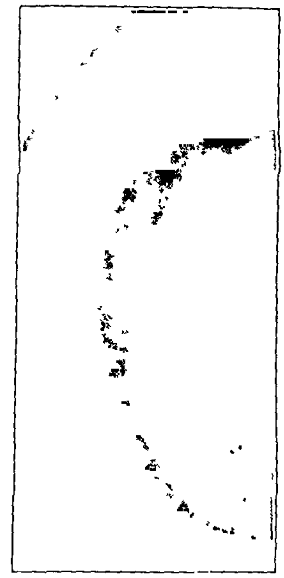


FIG. 7-C

Fig. 7-A: August 1946. Left ear shows nodular swelling of lobulus auriculae, thickening and swelling of helix, anthelix, tragus, antitragus, fossa triangularis, and crura anthelicis.

Fig. 7-B: Right ear has more pronounced swelling of lobulus auriculae and antitragus than the left, but less involvement of crura anthelicis.

Fig. 7-C: August 1946. Increased soft-tissue swelling and multiple fragments of ossific material may be seen.

FIG. 8

August 1946. Note broadening and thickening of bridge of nose.

Section A—Synovial Membrane: The synovial surface is smooth, with no synovial proliferation and no inflammatory reaction beneath the surface. There is moderate dilatation of subsurface capillaries (Fig. 9-C). The fat tissue has an occasional scattered lymphocyte and macrophage, but this is infrequent.

Section B—Articular Cartilage: The cartilage is completely absent over a large portion of the section and partially absent elsewhere (Figs. 9-A and 9-B). It is replaced by loose areolar connective tissue, containing only a few small nests of cartilage cells; the pattern here suggests the formation of fibrocartilage and some hyaline cartilage, such as that seen in callus formation. The subchondral plate is broken and discontinuous, but there is no evidence of proliferation of new-bone formation, eburnation, or other attempts to repair the broken bone plate. There is no inflammatory reaction anywhere, and no evidence of a pannus. The general appearance is that of a chondromalacia of undetermined cause.

III. *Ear* (Material taken from lobulus auriculae of left ear, February 1945)

Section A: The section consists of a thin sliver of normal cartilage, resembling normal articular cartilage in structure. On both surfaces there is an irregularity, due to apparent invasion of loose areolar and moderately vascular connective tissue.

Section B: This section reveals an area of scarring and an increased prominence of the capillaries, with infiltration of mononuclear inflammatory cells. Some of the collagen bundles are oedematous, shredded, and stain abnormally densely, as though undergoing some type of necrosis.

Section C (July 1946): This section consists of fairly dense collagen scar tissue, merging into large masses of newly formed fibrocartilage, which in a few places has progressed to hyaline cartilage. However, this does not have the appearance of normal hyaline cartilage, for the nests in which the cartilaginous cells lie are small and contain single cells, in contrast to the double and triple cell nests of normal hyaline cartilage. There are a few small spicules of bone, associated with the fibrocartilage formation. Only minute vessels are noted in the section, some of which are surrounded by groups of mononuclear cells.

Section D (July 1946): Most of this section is composed of fairly well-formed bone with an outer capsule of fibrocartilage and dense connective tissue, resembling periosteum. There is continued low-grade bone formation, as evidenced by the presence of osteoclasts and the formation of osteoid tissue, particularly about the periphery of the bone. The marrow spaces contain a few scattered plasma cells and loose areolar vascular connective tissue.

IV. *Nose* (Specimen taken from nasal septum, July 1946)

There is no identifiable cartilage in this section. There is a very thin strip of dense collagen, containing some scattered small capillaries and blood vessels, cuffed by mononuclear and polymorphonuclear cells;

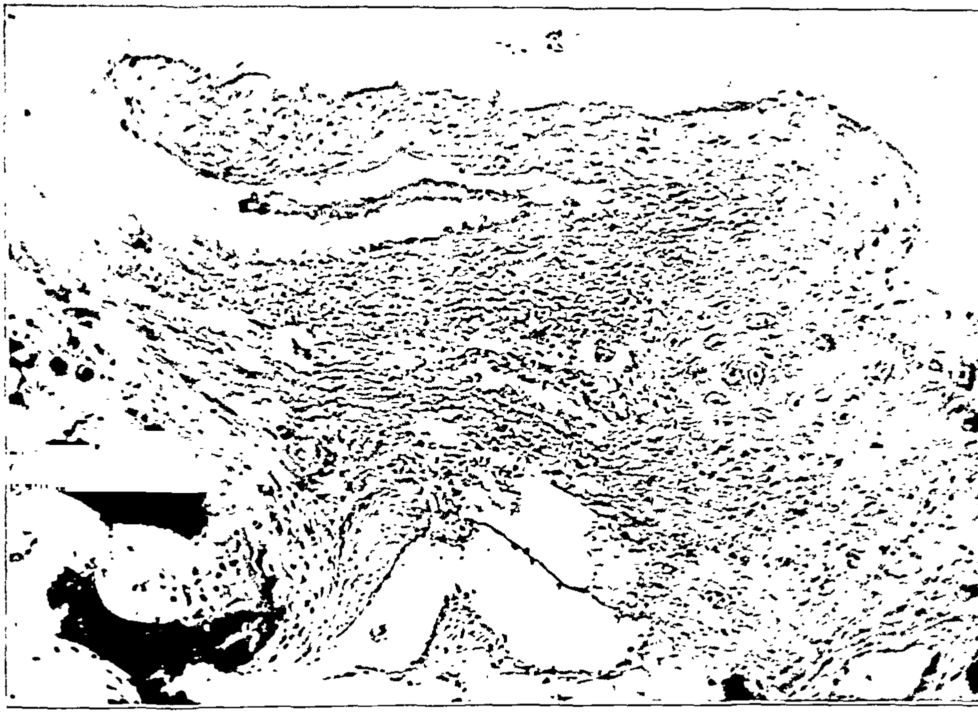


FIG. 9-A

Photomicrograph (× 200) of articular surface of left knee with complete loss of cartilage. Note small portion of subchondral bone plate on left. Mid-portion of subchondral bone is absent. On the right, the cartilage is completely absent and has been replaced by connective tissue with a nest of cartilaginous cells, resembling callus cartilage.

FIG. 9-B

Photomicrograph (× 128) of articular surface of left knee with some remaining cartilage. Note remaining articular cartilaginous plate above. The apparent calcification of cartilage is really a subchondral bone plate, distorted out of position by twisting of the section.

there is some mild shredding and oedema of the collagen. On the surface is a portion of mucosa with scattered infiltration of inflammatory cells between distorted glands.

V. *Trachea* (Specimen taken during tracheotomy, February 1945)

Section A: Most of the section is composed of dense collagen scar tissue, through which are scattered numerous small capillaries, associated with polymorphonuclear and mononuclear inflammatory cells and an occasional pigment-laden macrophage. The polymorphonuclear cells are more common here than in any of the other sections. In a few places, fragments of epithelium are present on the surface and merge with the scar tissue. In many places, epithelial glands are distorted by infiltration of inflammatory cells between and

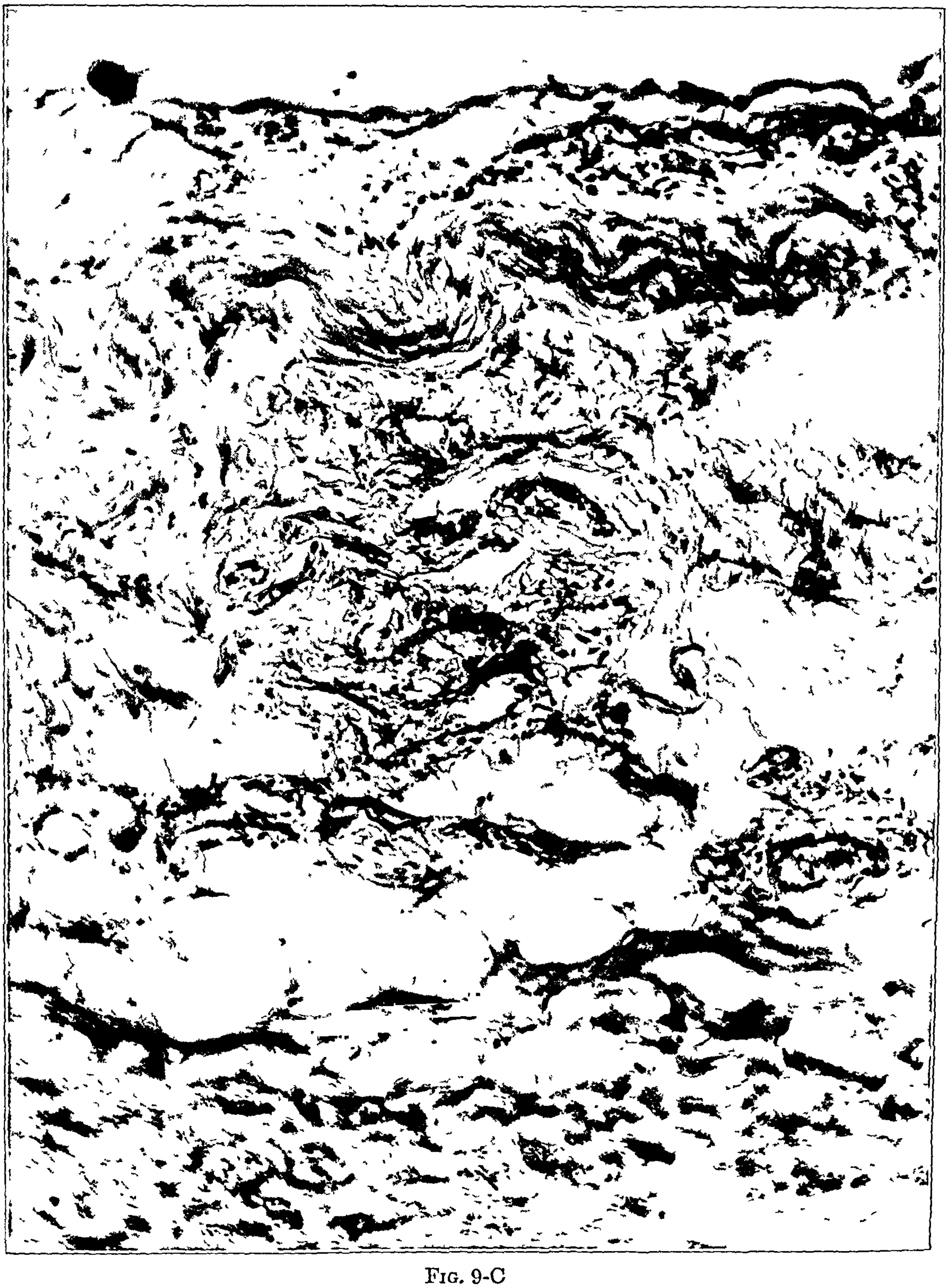


Fig. 9-C

Photomicrograph (× 275) of synovial membrane. Dilated capillaries may be observed beneath mesothelial lining. Very slight infiltration of mononuclear cells about blood vessels has occurred.

among them. Clearly recognizable cartilage is not present in most cases. Only a few fragments of oedematous, poorly staining, hyaline cartilage with foci of lacunae absorption and vascularization are noted.

Section B: This section contains a large amount of lining epithelium with submucosal glands. There are areas of mild cellular infiltration between the glands, and considerable connective-tissue scarring beneath the glands. A tiny fragment of hyaline cartilage is present, showing some early erosion and poor staining of the edges.

This case has been studied at the Army Institute of Pathology and by the Consultant Staff of civilian pathologists. For classification purposes, the case has been filed at the Institute as "Diffuse Chondritis and Perichondritis". The comments made there are quoted:

Colonel J. E. Ash, Scientific Director, Army Institute of Pathology: "In the case of M. W. (AIP Acc. 177038), it is the consensus that no categoric diagnosis can be made at present. The process apparently consists in part of diffuse degenerative change in cartilage, with some abortive attempt at cartilage formation, which one sees actively under way in the section taken from the ear. It is our opinion that the explanation may lie in some metabolic disorder. The possibility of these changes being due to syphilis cannot be excluded. However, except in the tissues submitted from the trachea, there is no evidence of inflammation."

Dr. Granville A. Bennett, University of Illinois: "Ten of the sections show no variations from normal. In four of the sections one sees proliferation of cartilage in the ear and some evidence of new-bone formation and of resorption in a section of bone. The section of trachea shows inflammation and fibrosis. Viewed in conjunction with the history, these sections are not very helpful and I am unable to offer an interpretation."

Dr. Walter Bauer, Massachusetts General Hospital: "The only abnormality that I could discern was that of perichondritis with associated inflammation and fibrosis. I saw nothing which would suggest a causative agent or a known disease. The history and signs are compatible with the diagnosis of rheumatoid arthritis."

COMMENT

A thorough search of both American and foreign literature, including periodicals and textbooks, reveals remarkably little on the subject of generalized perichondritis and chondritis. No case report was found of a clinical condition similar to the one described here.

In 1905, Barker presented a case at Johns Hopkins Hospital in which there was acute inflammatory involvement of multiple joints, as well as of the thyroid, cricoid, and tracheal cartilages, after acute gonorrhoeal urethritis. Barker believed this to represent a case of perichondritis of gonorrhoeal origin, although he was unable to demonstrate gonococci in any of the cartilaginous lesions.

Syphilis and tuberculosis have long been known to be etiological agents in perichondritis of the larynx and thyroid cartilage. Tuberculous laryngitis is a well-known complication of pulmonary tuberculosis. Three cases of syphilis of the larynx with perichondritis were reported in 1936 by Piquet and Quiret. A Soviet writer, V. D. Chaklin, in 1937 reported fourteen cases of tuberculous perichondritis of the ribs. Perichondritis of the ribs, larynx, thyroid, and of the cricoid and ear cartilage has also been produced by typhoid and paratyphoid infections, influenza, grippe, infections with *Bacillus pyocyaneus*, local ultraviolet therapy, radiation therapy, and carcinoma [1 6 10 12].

In addition, Jackson reports having seen perichondritis of the larynx with diphtheria, smallpox, scarlet fever, chicken pox, pneumonia, measles, typhus, Vincent's infection, anthrax, blastomycosis, actinomycosis, xanthoma, various dermatoses, herpetic and other ulcerative diseases, erysipelas, tonsillitis, and peritonsillar abscess. It was also observed accompanying wasting diseases, avitaminosis, and hemic dyscrasias. He noted that in sixty-eight cases, complicating typhoid fever, the disease occurred late, when toxaemia and asthenia were at their zenith and resistance was presumably at its nadir.

The ossification of both auricles, observed in the roentgenograms and microscopic sections, is a rare occurrence. Higbee states that it was first reported in 1866 by Bochdalek, in Prague, as an incidental finding in his dissection of a cadaver of an elderly person. Since then it has been occasionally noted [6] as a result of injury, including otohematoma

and frostbite, degenerative senile changes, infections, and constitutional disorders, such as diabetes. Ossification of the auricle resulting from perichondritis was reported by Bacon, but is exceedingly rare. The first reported case was by Gudden. The involvement of the helix, anthelix, and scaphoid fossa in this case coincides with the regions most frequently reported.

None of the known etiological agents could be proved in the case reported here. However, neither syphilis nor gonorrhoea could be completely excluded, inasmuch as there was a weakly positive blood Kahn and a positive complement-fixation test for gonorrhoea, despite denial by the patient that she had ever had either of these diseases or been treated for them. The significance of a one-plus or two-plus positive Kahn reaction is doubtful, inasmuch as this might be a non-specific reaction. In addition, the complement-fixation test for gonorrhoea appears to be a group and not a specific reaction, as Lisa believes that it is not uncommon to find meningococcal infections giving a positive gonococcal agglutination test.

SUMMARY

A case of rare occurrence has been presented in an attempt to secure a definite diagnosis. The multiple involvement of various types of cartilage in various parts of the body has resulted in an obscure clinical picture which does not conform to any known clinical entity. An effort has been made to report the case in sufficient detail and with sufficient illustrations to permit study and possible diagnosis by interested physicians.

NOTE: Appreciation is expressed to members of the Departments of Medicine, Ophthalmology, and Otolaryngology for their aid in the diagnosis and treatment of this case, and to James R. Lisa, M.D., Pathologist, New York City Hospital and Doctors Hospital, New York City, for his critical review of the manuscript.

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THE ACCESSORY TARSAL SCAPHOID *

BY ISADORE ZADEK, M.D., AND AARON M. GOLD, M.D., NEW YORK, N.Y.

The term "accessory tarsal scaphoid" (navicular) is used in this communication to indicate that accessory element which is juxtaposed medially and posteriorly to the tubercle of the tarsal scaphoid; it often gives the appearance of an extension of the scaphoid bone rather than resembling the other accessory scaphoid elements of rare occurrence,—such as the os supranaviculare, the os infranaviculare, or the true bipartite scaphoid.

That the tarsal scaphoid may have an accessory element has been known for many years. The first reference to it is credited to Bauhin, whose observations were recorded in 1605. Von Luschka, in 1858, in a monograph on amphiarthrosis, mentions the presence of such a bone bilaterally and symmetrically in the feet of an adolescent, seventeen years old. He noted that the juxtaposed surfaces of the scaphoid and accessory scaphoid bones were independent "joint" surfaces, and that the two bones were bound together by capsular strips. He stated, also, that the tibialis posterior tendon surrounded the accessory bone in such fashion that it might be considered as a sesamoid.

These observations immediately raised several questions: What is the exact relation of the accessory scaphoid to the scaphoid bone and to the tibialis posterior tendon? Is the accessory scaphoid a true tarsal bone, separate and distinct from the scaphoid bone, forming a true joint, and persisting as an independent bone; or is the accessory scaphoid merely an extra center of ossification for the tubercle of the scaphoid, which eventually unites more or less completely with the scaphoid and which possibly represents atavism toward a more primitive foot?

Significant contributions to the subject were made by Gruber, Bardeleben, Pfitzner, Féré and Deniker, Dwight, Monahan, Hohmann, and Geist. These reports indicate that a separate cartilaginous center for the tuberosity of the scaphoid may be found in the foetus; that the accessory scaphoid was present as a separate bone in about 10 per cent. of human beings and persisted as a separate bone in 2 per cent.; and that an imperfect division, indicated by furrows and irregularities of the scaphoid tubercle, was found in a considerably larger percentage.

A review of the literature disclosed that no roentgenographic studies had been conducted to determine conclusively the fate of the accessory scaphoid,—whether it persisted as an independent element or became incorporated with the scaphoid bone. Such a study is herewith presented.

The authors were fortunate to find children and adolescents, attending the Out-Patient Department of the Hospital for Joint Diseases, whose roentgenograms showed accessory scaphoids; these patients were re-examined, both clinically and roentgenographically, at intervals of one to eight years after the original x-ray examinations. In this manner the immediate fate of the accessory scaphoid was determined roentgenographically in these individuals. Eight such cases, representing fourteen accessory scaphoids, were studied with follow-up examinations.

That the accessory scaphoid may persist as an independent bone throughout adult life is well known by the presence of such accessory bones in the roentgenograms of the feet of elderly patients. Many such instances have been encountered.

The roentgenograms of the fourteen accessory scaphoids studied show that definite fusion between the accessory scaphoid and the scaphoid bone occurred in five instances, partial fusion occurred in three, and there was failure of fusion in six. It is evident, then, that bony union definitely occurs in a large proportion of cases and, conversely, that many accessory scaphoids do not unite with the scaphoid bone and persist throughout adult life. Roentgenograms of two illustrative cases are presented (Figs. 1-A, 1-B, 2-A, and 2-B).

* Presented at the New York Academy of Medicine, May 16, 1947.

Fig. 1-A

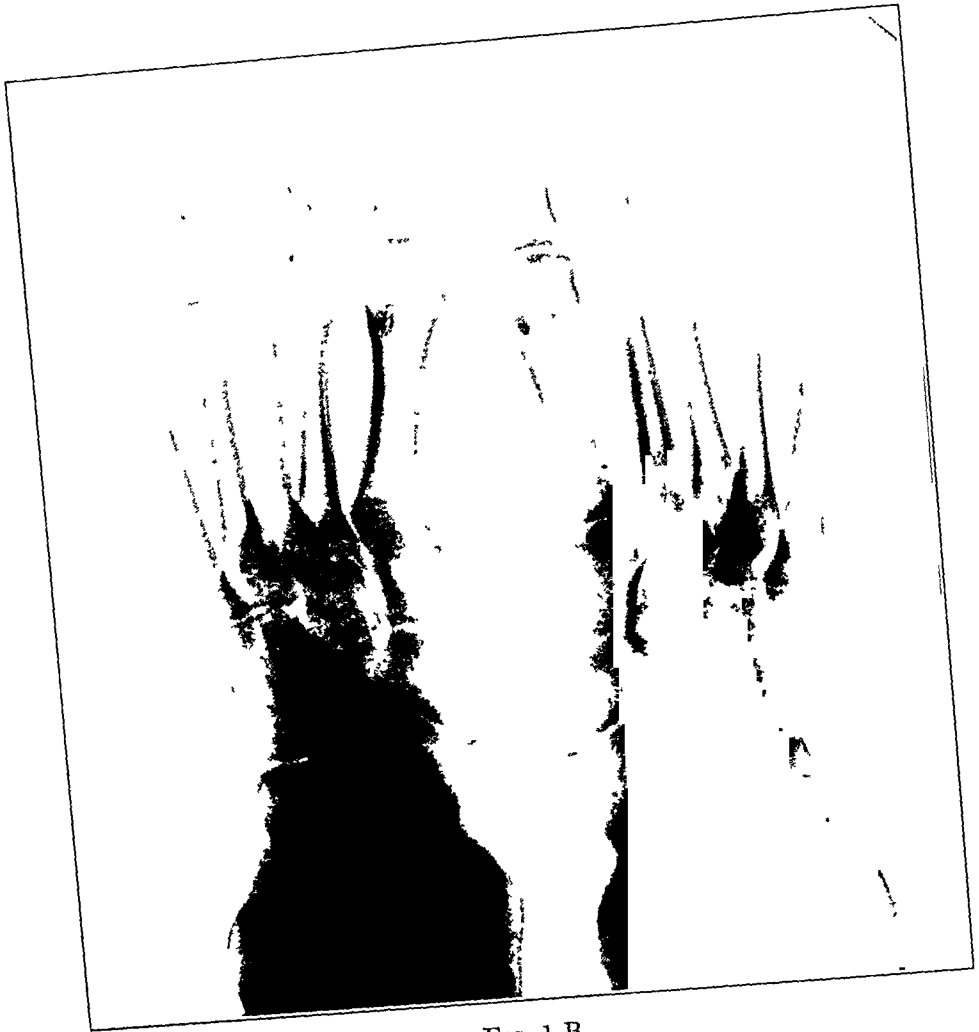

Fig. 1-B

Fig. 1-A: R. G., a girl, aged ten. Bilateral accessory scaphoid, as seen in 1933.
Fig. 1-B: Roentgenograms taken in 1942, when the patient was nineteen, show fusion of the accessory scaphoid on the left; the accessory bone persists on the right. The epiphyses in the long bones of the foot have closed.

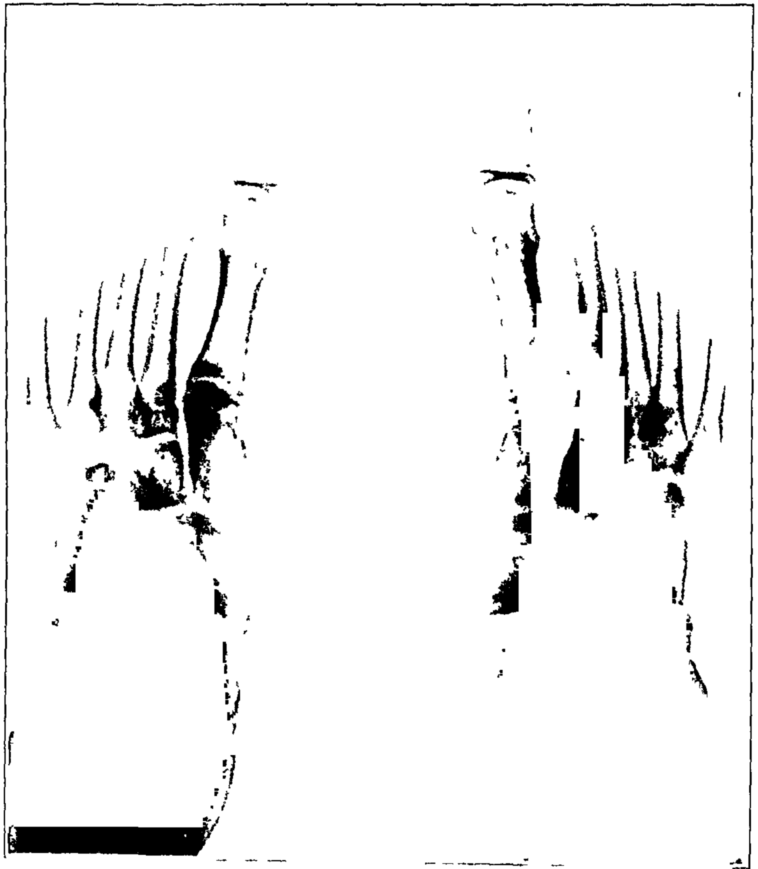

Fig 2-A

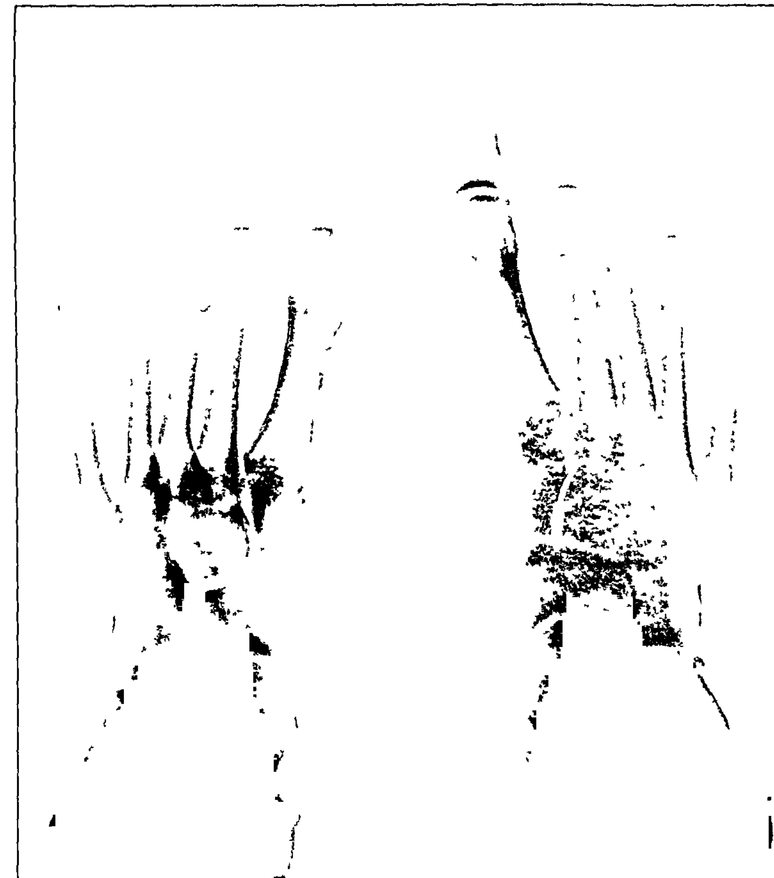

Fig. 2-B

Fig 2-A: A. G., a boy, aged fourteen. Appearance of bilateral accessory scaphoid in 1936.
Fig 2-B: Roentgenograms taken in 1942, when the patient was twenty, show complete fusion of the accessory scaphoid on the left; there is incomplete fusion on the right, with the furrow still evident.

Further evidence that union does take place, as well as the exact manner in which this occurs, was gleaned from microscopic studies.

Microscopic Considerations

Latten presented a case of an accessory scaphoid, including microscopic studies of the specimen removed at operation, and concluded that the tissue intervening between the scaphoid and the accessory scaphoid resembled a traumatized epiphyseal plate.

Francillon reported a study of twenty-nine cases of accessory scaphoids with microscopic studies on ten. He concluded, first, that the accessory scaphoid arose from a nidus of tissue in the substance of the tibialis posterior tendon, near its attachment to the scaphoid; second, in no instance did he find a true joint between the accessory scaphoid and the scaphoid bone; third, he found no hyaline cartilage, except for partial transformation from fibrocartilage to hyaline cartilage in one case; fourth, he believed that union might take place, accomplished by a vigorous ossification process at the juxtaposed surfaces.

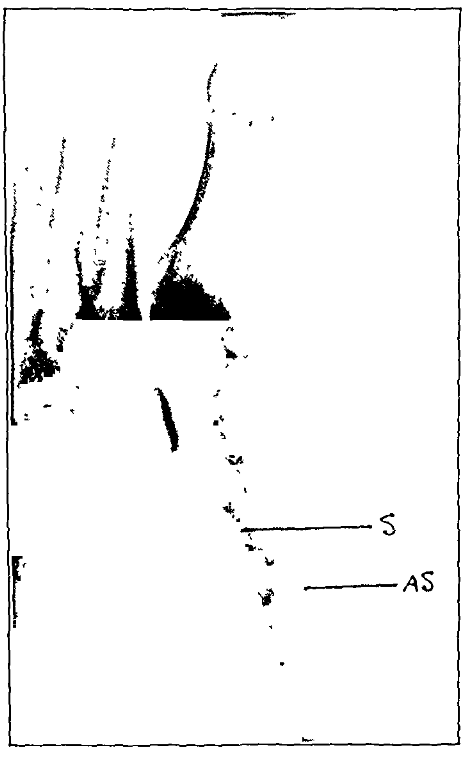

Fig. 3-A

Case 1. Roentgenogram showing the accessory scaphoid (*AS*) and its relation to the scaphoid (*S*).

The authors, too, were particularly interested in microscopic studies of the contiguous portions of the accessory scaphoid and the scaphoid tuberosity. It was estimated that, with the advantage of microscopic detail, one could determine the exact relationship of these two bones and the type of joint, if any, which existed between them. Fortunately, when an accessory scaphoid is removed, a portion of the usually prominent scaphoid tuberosity is also excised, thus preserving the anatomical juxtaposition of the two bones, which was essential for our studies. Numerous specimens of this type were available and the microscopic findings were instructive.

Only a few illustrative cases are presented, in order to avoid repetition. The cases to be cited show various stages of bony union between the accessory scaphoid and the scaphoid bone. In the first, the two articulating bones are separate and covered by fibrocartilage. The last case presents an instance of bony fusion, with only insular remnants of hyaline cartilage marking the site of the previously existing cartilage plate. The other three cases show intermediate stages.

Case 1. L. G., a girl, aged twelve, was admitted to the Hospital on April 10, 1940, because of painful prominences on the medial aspects of both feet and a tendency to turn her ankles. Examination of the feet showed that they were well balanced. There were painful prominences in the region of the scaphoid tubercles, more marked on the right side (Fig. 3-A). The tibialis posterior tendon inserted into this prominence bilaterally to a considerable degree. The accessory scaphoids and prominent portions of the scaphoid tuberosities were removed (Fig. 3-B).

The bones (accessory scaphoid and scaphoid tuberosity) are capped by a layer of dense fibrocartilage with an actual jointlike space between them. This space contains loose connective tissue, remotely resembling a synovial membrane. The tendinous fibers of the tibialis posterior on the outer side of the specimen (right side of the illustration) could well represent a capsular-like structure. There was very little endochondral activity below the fibrocartilaginous tissue. The outstanding picture is that of a joint, but with the articulating surfaces of fibrocartilage instead of hyaline cartilage (Fig. 3-C).

Case 2. A. S., a girl, aged twelve, was admitted to the Hospital on October 12, 1941, because of painful scaphoids. A large accessory scaphoid in the right foot is shown in Figure 4-A. A Kidner operation was performed bilaterally, and the accessory scaphoid and adjacent prominent portion of the scaphoid tuberosity were removed. The specimen removed from the right side presented a definite space between the two bones

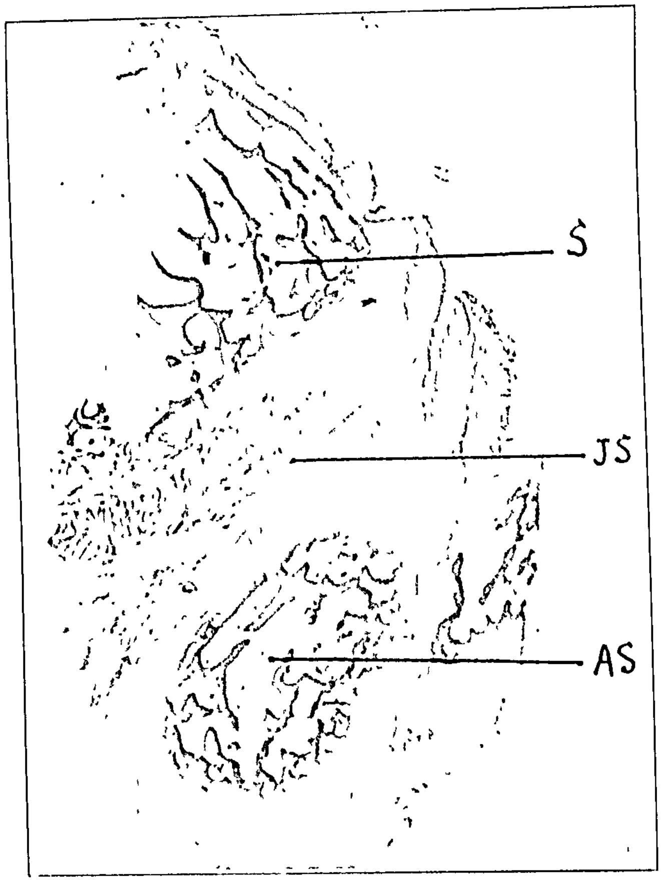

FIG. 3-B

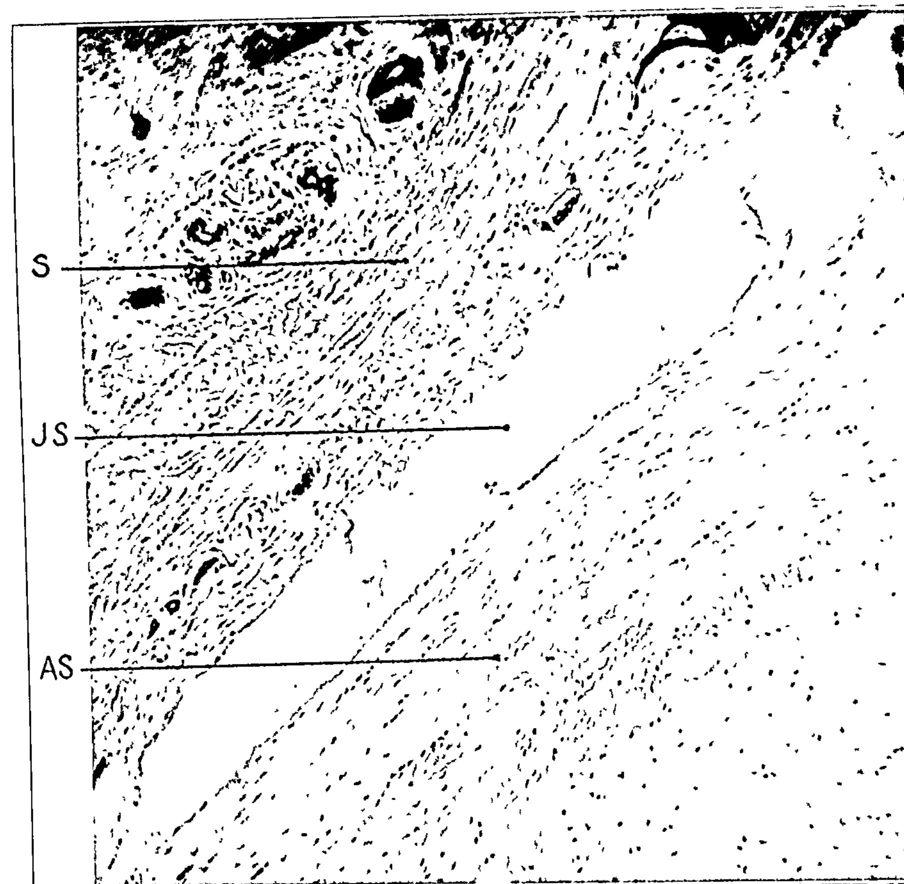

FIG. 3-C

Fig. 3-B: In low-power magnification, the contiguous surfaces of the two bones may be seen. The joint space (*JS*) separates the scaphoid (*S*) and the accessory scaphoid (*AS*).

Fig. 3-C: High-power magnification, showing the distinct separation (*JS*) between the two bones and the character of the soft tissue capping the bones.

(Fig. 4-B). This space permitted definite motion. Low-power and high-power views of the specimen (Figs. 4-C and 4-D) show the accessory scaphoid bone and the adjacent piece of the scaphoid tuberosity. The two

Fig. 4-A

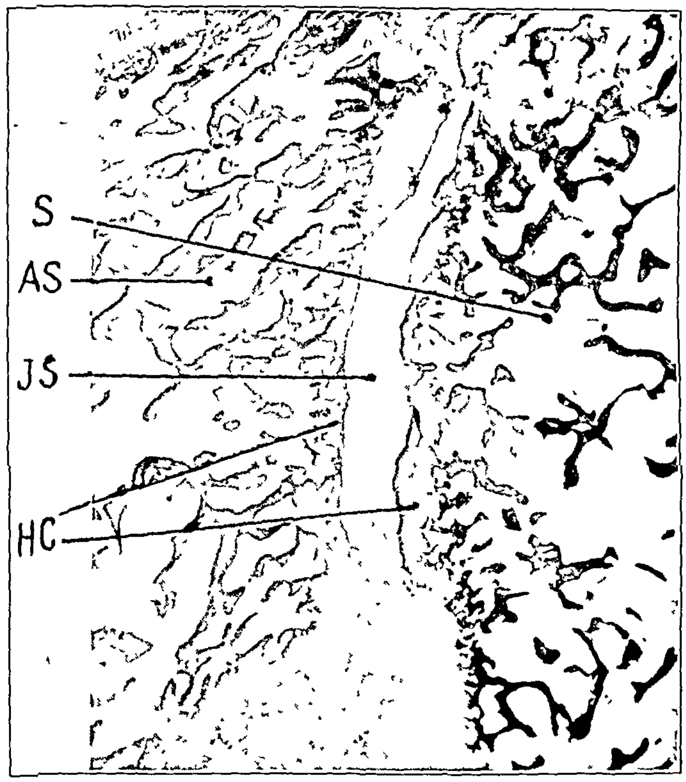

Fig. 4-C

Fig. 4-A: Case 2. Roentgenogram of the right foot, showing a large accessory scaphoid.
Fig. 4-B: Photograph of the specimen removed at operation. A definite joint space (*JS*) is visible grossly, separating the accessory scaphoid (*AS*) from the scaphoid tuberosity (*S*).
Fig. 4-C: Low-power magnification of microscopic section shows the joint space (*JS*) more clearly. The juxtaposed bony margins of the scaphoid (*S*) and accessory scaphold (*AS*) are capped by irregular, eroded, and degenerated hyaline cartilage (*HC*). Fig. 4-D: High-power magnification, showing hyaline cartilage at the joint space.

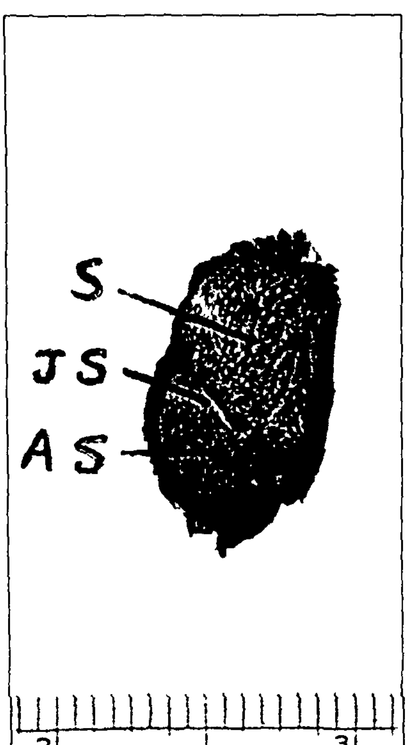

Fig. 4-B

Fig. 4-D

are capped by a fairly thick, but irregular, layer of articular type of hyaline cartilage, separated by a jointlike space.

CASE 3. B. G., a girl, aged thirteen, was admitted to the Hospital on January 9, 1940, because of pain on the medial aspects of the feet of a year's duration. Bony prominences were present at the site of greatest pain: this was more severe on the right and tenderness was present on this side. Roentgenograms (Fig. 5-A) showed an accessory scaphoid. Most of the tibialis posterior tendon was inserted into the accessory scaphoid on the right, but could be seen extending beyond this bone on the left. At operation, the superficial fibers of the tibialis posterior tendon were found to extend beyond the accessory scaphoid and the scaphoid tuberosity on the right.

A low-power magnification of the specimen removed (Fig. 5-B) shows that the two bones were joined by a thick layer of fibrocartilage (plate). At the outer corner of the scaphoid fragment (right side of the illustration), adjacent to the accessory scaphoid, there is marked cellular activity with giant-cell osteoclasts, dense fibrous tissue, and even granulation-like tissue, as if a tearing away and repair had taken place recently. Marked endochondral ossification is evident on the accessory side of the cartilage plate. Bone sclerosis is present at this site. Figure 5-C is a higher-power view which includes the "traumatized" area.

CASE 4. N. R., a boy, aged thirteen, entered the Hospital on May 16, 1941, because of pain on the medial aspects of both feet when walking. Bilaterally the feet were flat and a prominence was present on the medial aspect of the mid-tarsal region; these prominences consisted of the accessory scaphoid (Fig. 6-A) and adjacent portion of the scaphoid tuberosity.

On microscopic section a large accessory scaphoid is seen, separated from the scaphoid tuberosity by a hyaline-cartilage plate (Figs. 6-B and 6-C), with marked endochondral ossification on both sides of the cartilage plate and encroaching upon the plate, which is quite narrow in a few areas. In fact, a longitudinal cleft already connects the marrow spaces of the two related bones, and it is probable that both bones would soon have become fused had the operation not been performed.

CASE 5. E. D., a man, aged twenty-six, was admitted to the Hospital on October 11, 1934, because of pain in the right foot for the preceding ten years, aggravated by standing and walking. He had received treatment for flat feet, with some improvement. Roentgenographically, an accessory scaphoid was seen, apparently incompletely united (Fig. 7-A). At operation, the tibialis posterior tendon was found to insert partially into the accessory scaphoid and partially into the scaphoid bone. Low-power and high-power views of the specimen removed (Figs. 7-B and 7-C) show practically complete bony union of the two bones under consideration. A linear zone of thickened bone trabeculae marks the site of the previously existing intervening tissue, with small islands of hyaline cartilage undergoing degeneration and transformation into bone.

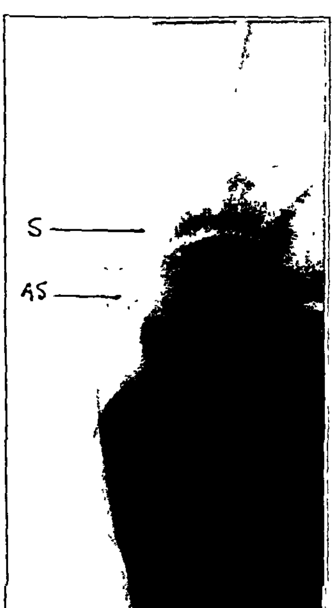

FIG. 5-A

Case 3. Roentgenogram shows the scaphoid (*S*) and accessory scaphoid (*AS*).

DISCUSSION

The microscopic studies show that the accessory scaphoid and the scaphoid bone, having the usual cancellous trabecular structure of tarsal bones, were joined by a layer of soft tissue. This soft-tissue plate consisted of hyaline cartilage, dense fibrocartilage, or a mixture of the two. The plate varied in thickness, was occasionally beset with longitudinal or transverse clefts, and frequently showed very active ossification on each side.

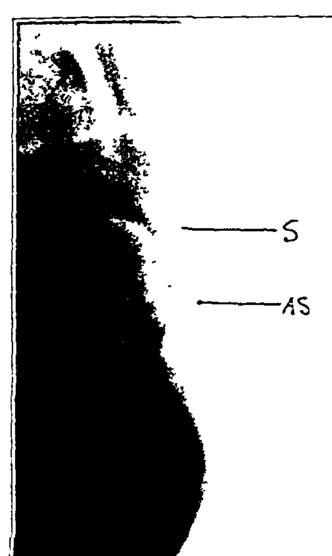

FIG. 6-A

Case 4. Roentgenogram showing the accessory scaphoid (*AS*) and scaphoid (*S*).

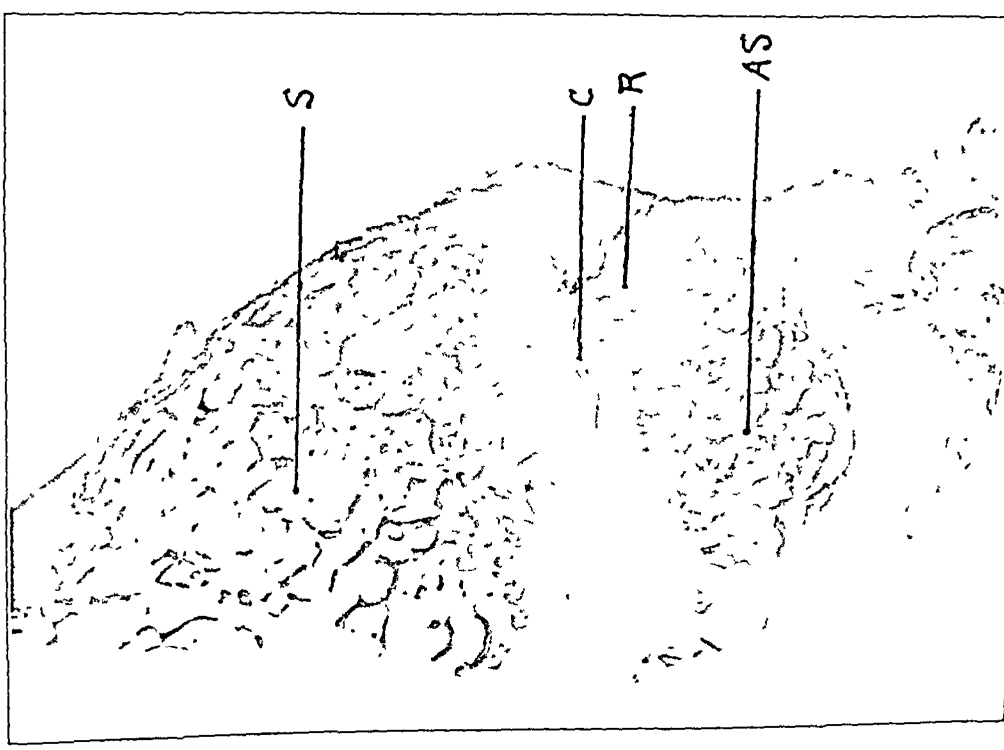

Fig. 5-B

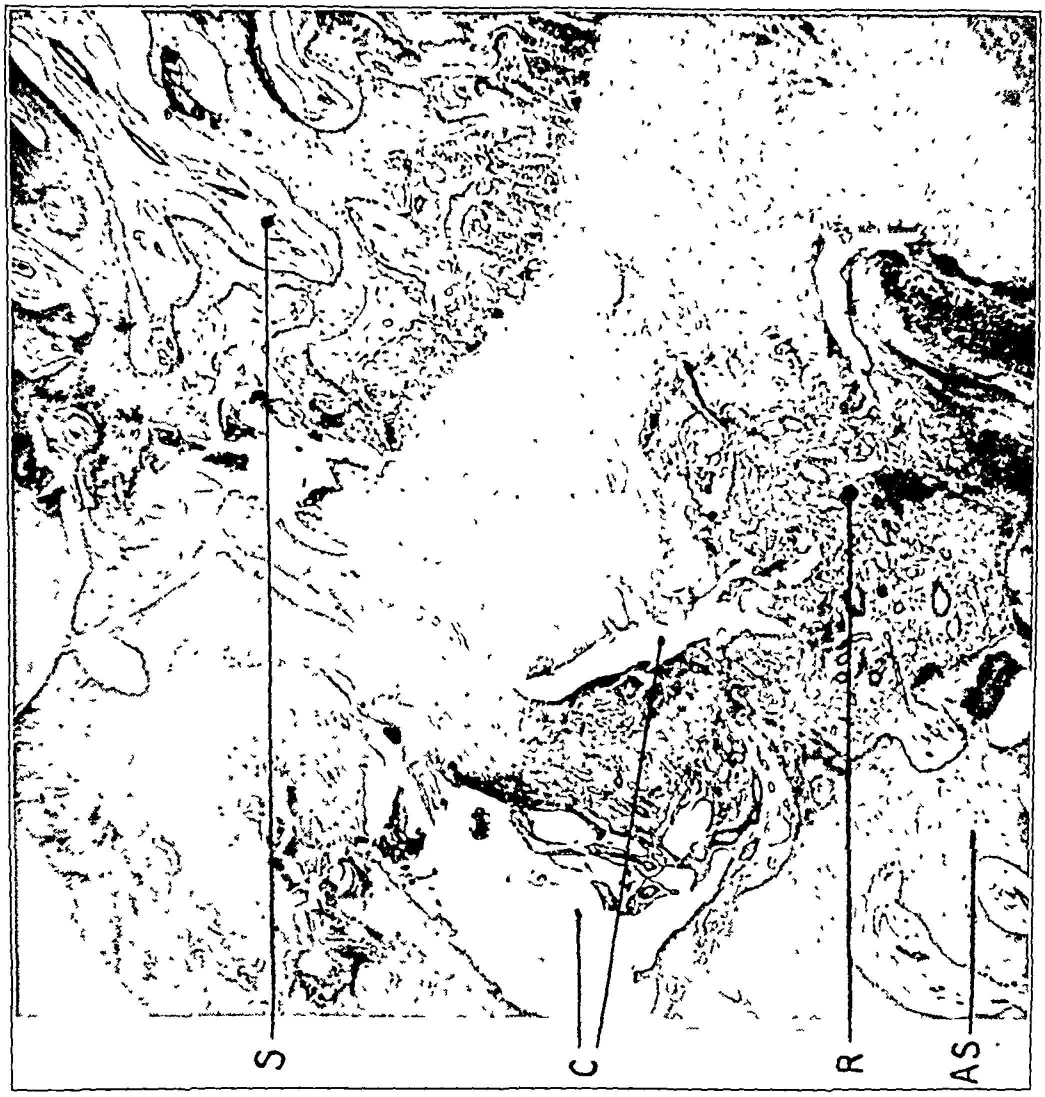

Fig. 5-C

Fig. 5-B: Case 3. Low-power magnification of microscopic specimen. The cleft is labeled *C*; *R* represents a site of active repair.
Fig. 5-C: High-power magnification. Traumatic cleft is shown at *C*, area of fibrous repair at *R*.

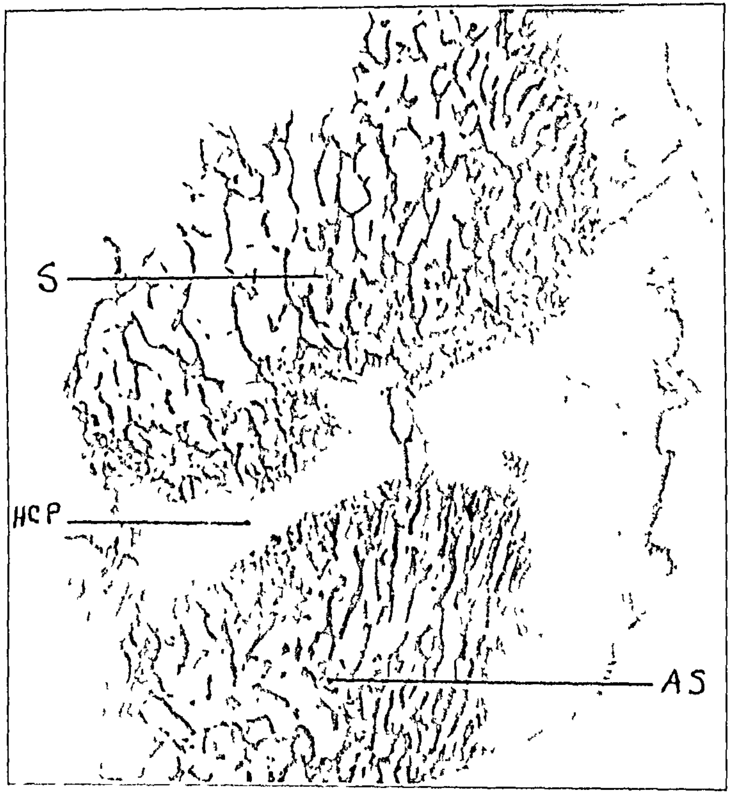

FIG. 6-B

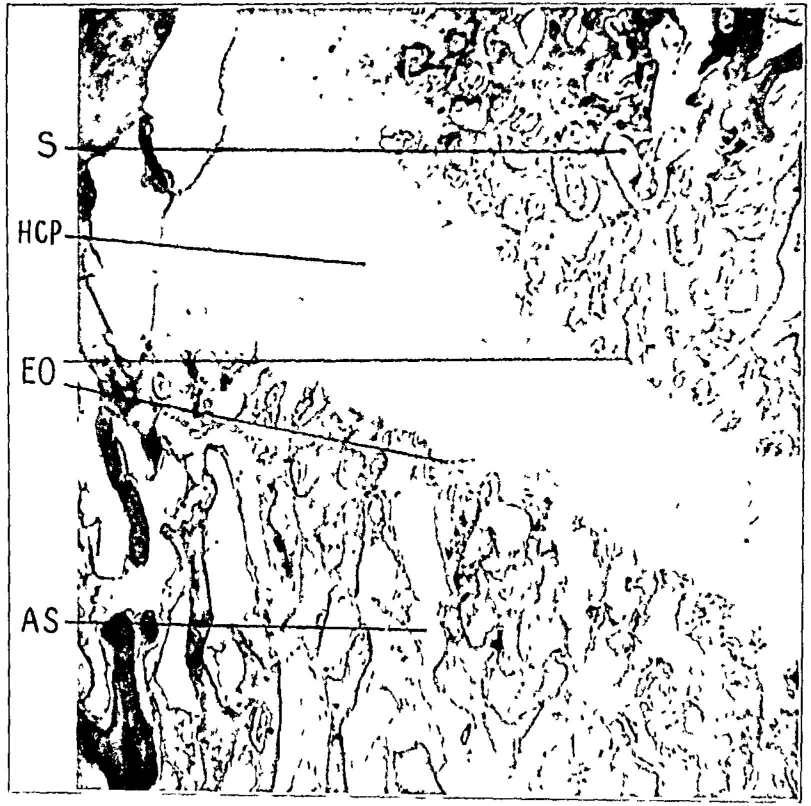

FIG. 6-C

Fig. 6-B: Case 1. Low-power magnification of microscopic section. The hyaline-cartilage plate (*HCP*) unites the two bones.
Fig. 6-C: High-power magnification. Very active endochondral ossification (*EO*) is noted, encroaching on the intervening cartilaginous plate (*HCP*). (This photomicrograph has been reversed.)

From the marked ossification activity which was in progress on both sides of the plates, it appeared that the plates were well on the way to complete obliteration. That this did not hold true in all instances was attested by the clinical fact that accessory scaphoids frequently persist into adult life. It must be assumed, therefore, that in some cases, at the time growth ceases and the epiphyses of the skeleton close, or soon thereafter, ossification of the intervening plate between the accessory scaphoid and the scaphoid bone stops without the plate having been completely ossified, so that a synchondrosis remains.

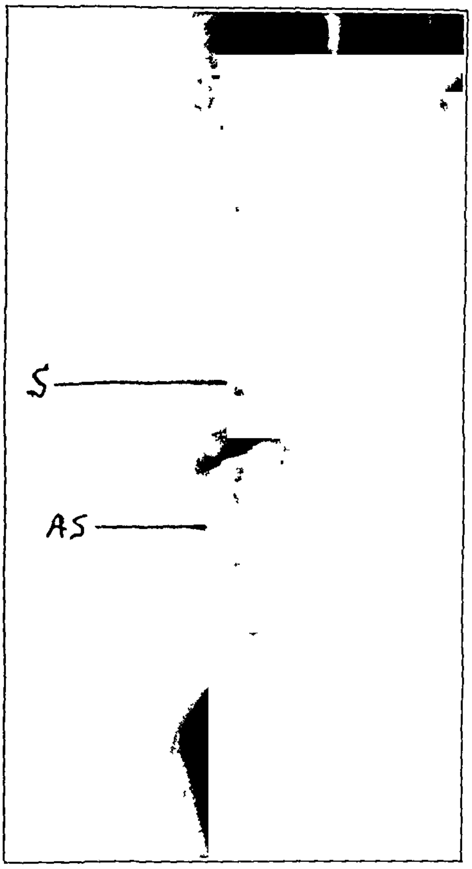

FIG. 7-A

Case 5. Roentgenograms show the accessory scaphoid (*AS*) and the scaphoid (*S*), incompletely united.

In none of the cases studied was a well-developed, freely movable joint found. with smooth hyaline articular cartilage capping each bone, and with the two articulating bones bound together by a synovial-lined fibrous capsule, such as we would expect to find in the talonavicular joint. In one instance (Case 1) an apparent joint space was present, but the two bones were capped by fibrocartilage instead of hyaline articular cartilage. In another instance (Case 2) a fairly wide but irregular horizontal cleft, definitely jointlike, was present, with a fairly thick layer of hyaline cartilage capping the two articulating bones on both sides of the cleft and permitting some motion in the gross specimen. The hyaline cartilage, however, although conceivably articular in character, was not very regular or smooth. One might claim that the cleft was artificially produced by trauma, a sudden strain on the tibialis posterior tendon tearing away the accessory scaphoid from the scaphoid tuberosity, producing a rift in the intervening cartilage plate, and causing a pseudarthrosis. In fact, the specimens frequently exhibited evidences of trauma in the form of hemorrhages, organizing fibrous tissue containing giant-cell osteoclasts or chondroclasts, and callus-like reparative tissue located subchondrally. This explains the acute symptoms and localized pain often found in patients with an accessory scaphoid. This is quite analogous to the strain on the tibial tubercle exerted by the patellar ligament in cases of Osgood-Schlatte disease, as discussed by Uhry. The accessory scaphoid may or may not be painful or sensi tive to pressure. Originally one of the authors (I. Z.) thought that, if the accessory sca phoid was painful, it was the result of mechanical strain in poor balance of the foot. Th observations made here have shown that this was not the only explanation, as traum may occur in feet which are reasonably well balanced.

In most of these cases showing an accessory scaphoid, the tibialis posterior tendon i attached to the scaphoid tubercle to a greater degree than normally exists. This can b shown clinically, as reported by Zadek in 1926.

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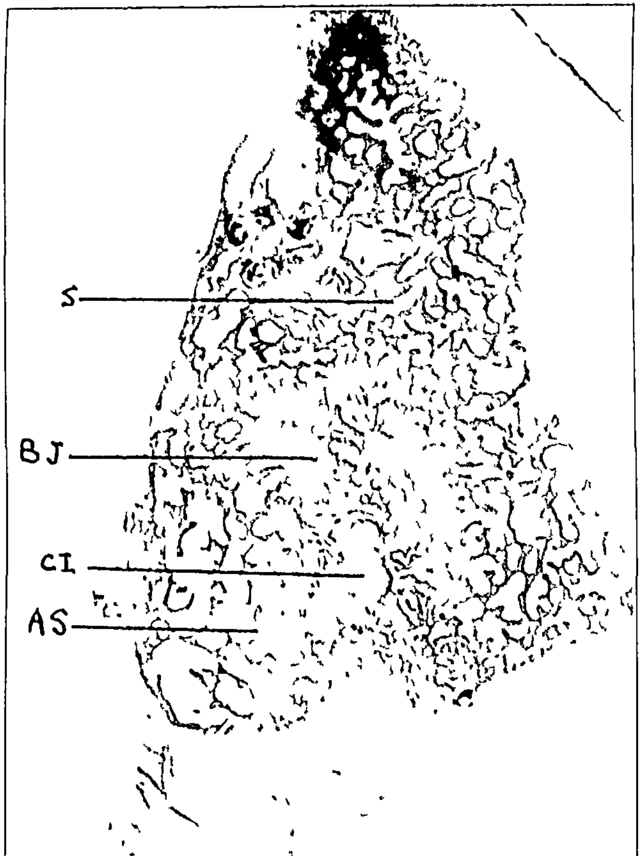

Fig 7-B

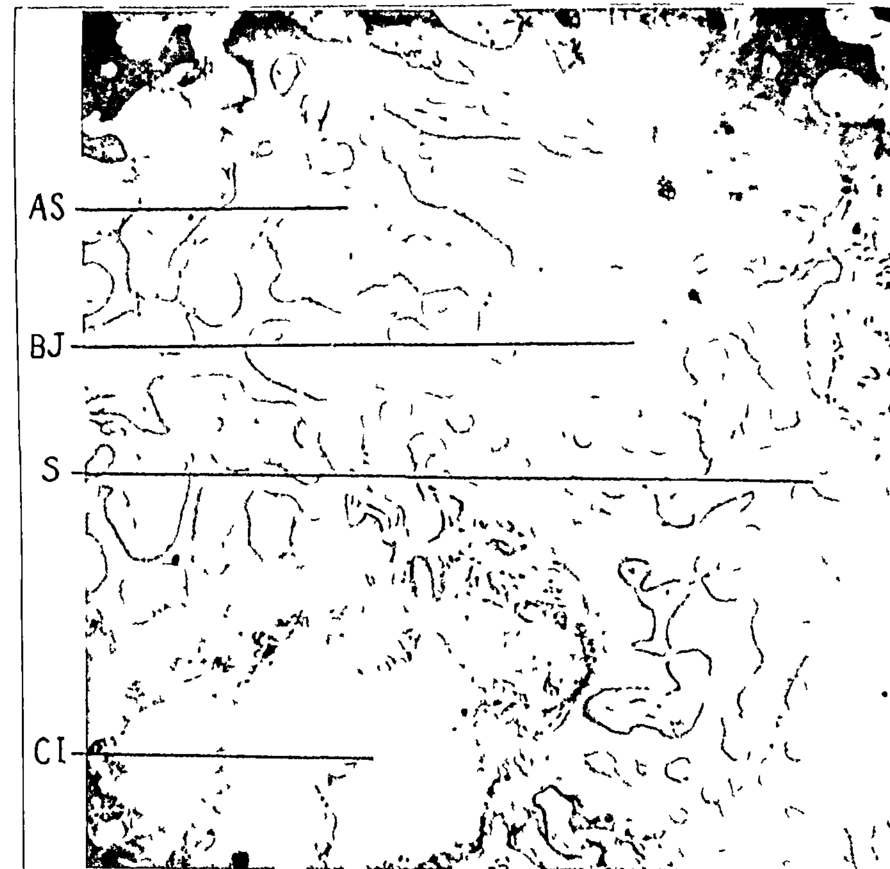

Fig 7-C

Fig 7-B Low-power magnification of microscopic section This reveals bony junction (*BJ*) of the two bones *CI* represents a residual cartilaginous island.
Fig 7-C: In a high-power magnification, the bony junction (*BJ*) and the cartilaginous island (*CI*) are noted in greater detail

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VASCULAR COMPLICATION OF DISC SURGERY*

BY EDWARD C. HOLSCHER, M.D.,† ST. LOUIS, MISSOURI

Accidental injury to the great vessels anterior to the lumbar vertebrae at the time of disc removal is known to this writer to have occurred at least five times in this country during the last five years.

In the case to be reported, the second known, the complication occurred when a very able and well-trained surgeon in a military hospital was making a distinct effort to prevent just such an incident, while operating upon a white man, twenty-three years old.

The surgeon was using a so-called pituitary rongeur in the fourth interspace on the left; as a precautionary measure, he was making a depth sounding for the anterior portion of the annulus fibrosis with the closed instrument, when, with surprising ease, it slipped through the interspace. As the instrument was withdrawn, a copious welling-up of dark blood immediately occurred in the joint. The interspace was packed with gauze and the procedure was suspended, since it seemed quite obvious that damage had been done to the great vessels. The anaesthetist was informed of the incident and the patient was carefully observed. The blood pressure, which had been 110 systolic, 60 diastolic, at the start of the operation, was found to be 100 systolic, 50 diastolic. After about fifteen minutes, no further circulatory change had occurred. The pack was then removed from the interspace without further blood collecting there, and the operation was resumed. At the end of the procedure, there was still no appreciable circulatory disturbance. The patient was turned to a supine position and the abdomen was carefully palpated. Nothing unusual was found except slight muscle spasm of the lower anterior abdominal wall.

The administration of glucose, which the patient had been receiving during the operation, was completed; he was then given 500 cubic centimeters of plasma. After it had been determined that there was no

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1948.

† Formerly Colonel, Medical Corps, Army of the United States.

particularly unusual reaction, the patient was returned to the ward in a stable condition His blood pressure remained around 100 systolic, 50 diastolic. The following day he experienced a sharp throbbing pain in the right lower quadrant, together with inability to expel gas or to empty his bladder. The peristaltic sounds were distant. There was no unusual febrile reaction. He reacted only moderately to frequent enemas and small injections of prostigmine. Catheterization was necessary There was moderate tenderness in the right inguinal region. A bruit was heard over the right lower quadrant and down the right femoral vessels, similar to that often heard over the placenta at terminal pregnancy The cardiac rhythm was regular with a rate of 112. The blood pressure was 120 systolic, 44 diastolic Examination showed the heart to be normal, except for a loud systolic murmur at the pulmonic area and a softer systolic murmur at the apex. These murmurs had not been found previously. The right dorsalis pedis pulsation could not be felt. No blood pressure was obtained in the right leg. The blood pressure in the left leg was 120 systolic, 70 diastolic. There was some prominence of the veins of the lower abdomen and thigh These findings were considered characteristic of retroperitoneal hemorrhage and the development of an arteriovenous aneurysm.

For several days the condition of the patient remained about the same, except that he began voiding and the abdominal distention lessened His general circulation remained stable, and he complained surprisingly little. The affected extremity did not swell or change color, and it could be moved freely. Four days after the operation, roentgenograms of the abdomen showed only increased gas in the large bowel. The patient was slightly febrile and moderately anaemic, but was eating well of a light diet. His abdomen was still slightly distended, but was not uncomfortable. He was expelling flatus and was voiding. A palpable thrill was easily felt, just below and to the right of the umbilicus. Definitive diagnosis of an arteriovenous aneurysm was made, and it was decided to keep the patient strictly on bed rest. Repair of the aneurysm was contemplated at some future date.

A month after the operation, the right dorsalis pedis was fairly easily palpable. A roentgenogram of the chest revealed no cardiac enlargement The blood pressure was 130 systolic, 60 diastolic. The patient was afebrile and his anaemia was only slight. There had been some change in the physical findings in the lower abdomen, characterized by lessening of the bruit and thrill in this area. Close observation of the patient was continued during the next five months He was allowed to get up after the second month, but his physical

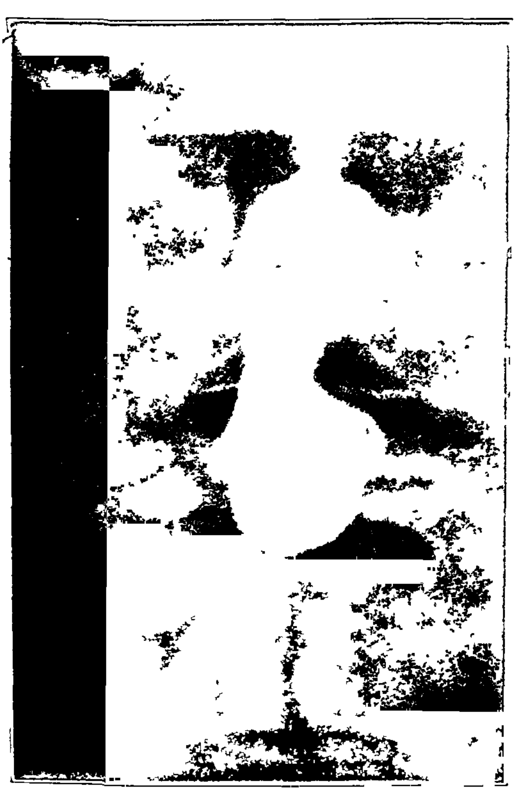

Fig. 1

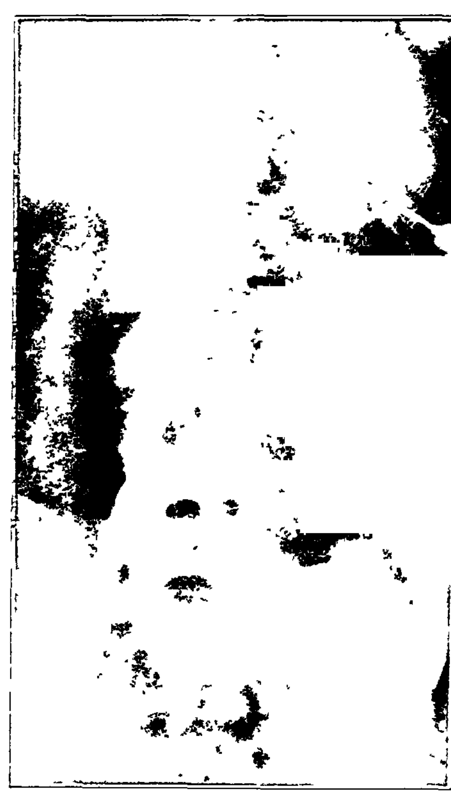

Fig. 2

Fig. 1: Pantopaque myelogram localized the disc lesion at the fourth lumbar vertebra on the left.
Fig. 2: An incidental arteriogram, showing relationship of vessels to the interbody joints. (Obtained through the courtesy of William F. Melick, M.D.)

Fig. 3: *Drawing of findings and th* operation by the vascular surgeon.

Fig. 4: Schematic representation o *vascular injury by a so-called pituitar* rongeur.

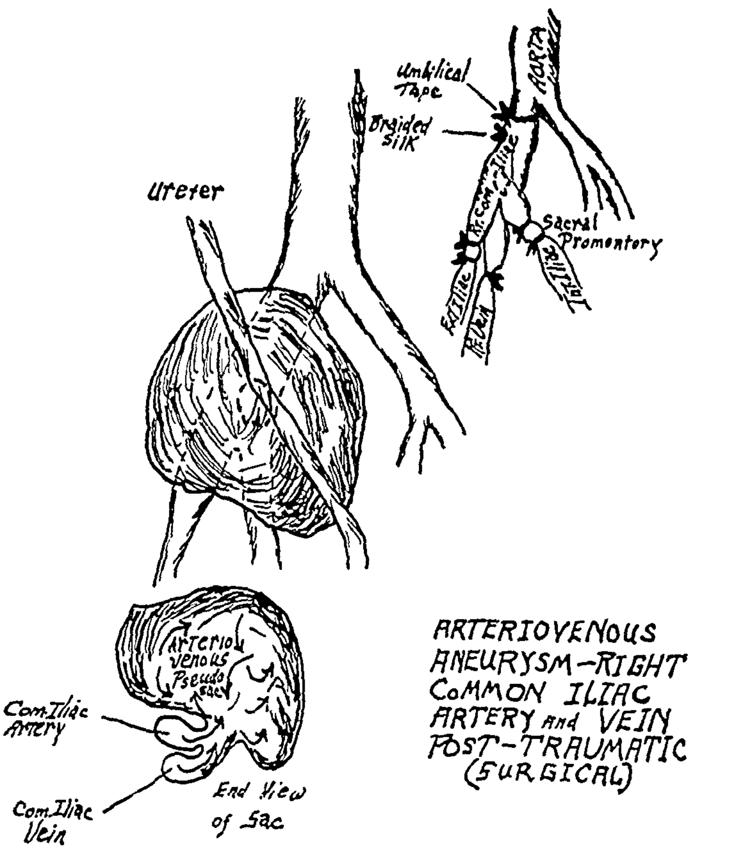

FIG. 3

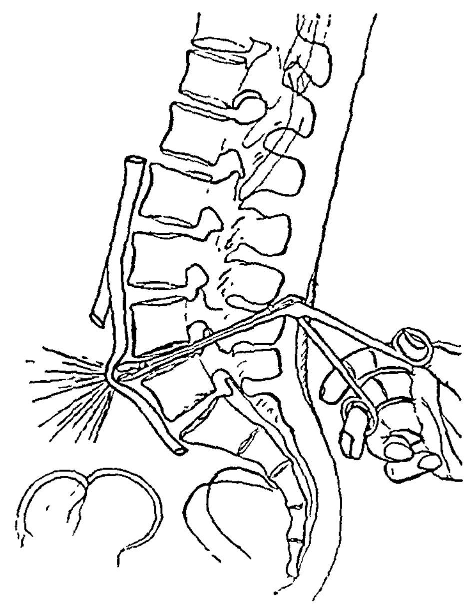

FIG. 4

activity was restricted. No further cardiovascular changes occurred. Heart roentgenograms and repeate electrocardiograms continued to show normal findings.

Six months after disc surgery, corrective vascular surgery was carried out transperitoneally through : lower right rectus incision. An aneurysmal sac, measuring approximately three centimeters in diameter, wa found at the right common iliac vessels. The sac was obliterated by ligation of the artery and vein above anc below it. After this procedure, the patient was given a right lumbar sympathetic block. Blocks were repeatec daily for several days. The postoperative course was without incident. He was allowed up after a week, witl permission to increase gradually his physical activities. Walking a moderate distance at first caused vagu aching in the right calf, which seemed to be relieved by an elastic stocking. After a short time, the patien abandoned the use of this support and had no further complaint. He remained, throughout hospitalization unusually grateful for the immediate relief he had obtained from the sciatic pain by the disc surgery. He wa never made aware of the exact nature of his vascular condition, which had necessitated operation.

DISCUSSION

The ease with which this complication can occur can only be appreciated by the surgeon in whose hands such an unfortunate incident has happened. The gravity of the complication would indicate that prevention would be the best cure, but it must be emphasized again that the accident reported here happened while the surgeon was attempting to avoid just such a complication.

Four other known but unpublished instances of similar vascular damage, each with grave result, are known to have occurred. The fatal outcome in the majority of these cases places this complication among the dire surgical emergencies. Upon the slightest suspicion of vascular injury, large amounts of whole blood should be made available at the earliest possible moment. Decision in the diagnosis and treatment may be difficult. In any instance where the patient's circulatory condition shows marked change, however, there would seem real indication to attempt immediate repair of the vascular injury. Because of the potential danger to a patient undergoing disc surgery, it would seem advisable to determine routinely before operation the blood type and the Rh factor.

CRITERIA FOR SPINE FUSION FOLLOWING REMOVAL OF PROTRUDED NUCLEUS PULPOSUS *

BY GUY A. CALDWELL, M.D., AND WILLIAM B. SHEPPARD, M.D., NEW ORLEANS, LOUISIANA

From the Department of Orthopaedics, Ochsner Clinic, New Orleans

Most orthopaedic surgeons who have written about the treatment of the typical disc syndrome during the past ten years have favored removal of the protruded disc, combined with spine fusion in a large proportion of cases. Ghormley and associates, in 1942, advised spine fusion, if sciatic pain exists with spondylolisthesis, spondylolysis, lumbosacral arthritis, or a combination of these. In 1944, Smith, Deery, and Hagman extended these indications to include "an unstable joint, as determined by roentgenogram, with or without symptoms of back pain". Barr wrote, in 1947, "It appears probable that the trend is toward fusion of the spine, at the time of laminectomy, in an increasing number of these cases. The thesis that every patient should have a spine fusion done at the time of laminectomy is tenable." Thus, a wave of enthusiasm for the combined operation has been engendered, which may not be justified by the results obtained.

The results of laminectomy without fusion have been reported by Lenhard, Love, Barr, and others; and, although they indicate that the back and sciatic pain is relieved in 53 to 67 per cent. of the cases, as reflected in the answers to questionnaires sent to the patients, many were not completely relieved and still complained of some degree of pain in the back. It has been assumed, therefore, that the pathological changes in the disc progressed after operation, because of instability of the joint; and that these changes could have been prevented by supplementing removal of the protruded nucleus with fusion of the involved segments of the spine. Comparison of groups of cases with and without spine fusion, published by Barr; Ghormley, Love, and Young; and Smith, Deery, and Hagman, indicates a higher percentage of good results from the combined procedure, based on follow-up examinations or answers to questionnaires sent to the patients. However, reports from an insurance company by Marble and Bishop indicate that the combined operation gave good results in only 14 to 40 per cent. of cases.

Since 1938, patients with the typical disc syndrome have been examined and treated at this Clinic by the Departments of Orthopaedic Surgery and Neurosurgery. A few combined operations were performed in the earlier years, but it was noted that most patients were relieved of all disabling symptoms by removal of the protruded nucleus pulposus without the fusion operation. Therefore, the policy of conservative treatment was adopted for most patients; and, if this failed after a reasonable trial, Dean H. Echols, neurosurgeon at the Foundation Hospital, operated to remove the protruded nucleus. Spine fusion has been performed *only if disabling backache has persisted for a year or more after laminectomy;* and as a result, few fusions have been necessary. Since this plan of treatment is contrary to present trends and yet the results have been satisfactory both to our patients and to ourselves, it would seem worth while to present an analysis of our observations of patients operated upon by Echols at this Clinic, three to seven years ago. During this period, 151 laminectomies were performed; and, of the patients operated upon, ninety-eight returned for re-examination.

Erroneous impressions of the results in some of the previous reports may have arisen from the use of questionnaires answered by the patients. Additional errors may have resulted from inclusion of cases in which protrusion of the nucleus pulposus was not demonstrated at operation. To obviate these errors, this study has been restricted to the seventy-

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois January 27, 1948.

five patients in whom protrusion of the nucleus pulposus was proved at operation, an who have returned for roentgenographic and clinical re-examination. Cases which wer eliminated from this study included (1) those patients upon whom spine fusions were don at the time of the original operation; (2) those patients in whom no definite pathologic conditions could be found to account for symptoms; and (3) those patients in whom othe pathological lesions could be demonstrated to explain the symptoms. Of the remaining 11 patients who might have returned for re-examination, only seventy-five returned. In orde to make the observations as impersonal and objective as possible, the patients were ex amined and the results evaluated by one of the authors (W.B.S.), who had had no previou contact with this group of patients. An attempt has been made to answer the followin questions:

1. What are the results in terms of function?
2. What changes occur in and about the intervertebral disc from three to seven yea after operation, as observed in the roentgenogram?
3. Do the functional end results correlate with the pathological changes in the disc
4. Are the end results related to the existence of anomalies and thin discs?
5. Does protrusion of the nucleus pulposus recur consistently with anomalies o postoperative narrowing of the disc?

The functional results were tabulated as *excellent*, *satisfactory*, or *unsatisfactor* Results were considered *excellent* if the patient was in complete agreement with the exami ner that there was no disability resulting from the original pain in his lower extremit or back, or from the operation performed. Results were *satisfactory* if the patient, in spit of minor difficulty with his back or limb, returned to full-time work without disability *Unsatisfactory* results were obtained in those patients who could not work full time becaus of persistent pain, or in those patients who were completely relieved of the initial pain i the back or limb, but in whom symptoms developed later, necessitating a second operatio

TABLE I

FUNCTIONAL RESULTS IN SEVENTY-FIVE CASES OF PROVED PROTRUSION OF THE NUCLEUS PULPOSUS (SURGEON'S EVALUATION)

Result of Operation	No. of Cases	Per cent
Excellent	32	42.67
Satisfactory	30	40.00
Total good results		82.67
Unsatisfactory	13	17.33
Total	75	100.00

Good functional results—that is, the total of *excellent* and *satisfactory* results—were obtained in sixty-two patients, or 82.67 per cent. of the cases (Table I). To these might be added the six recurrent cases (Table II) in which good results were certainly obtained before and after recurrence,—a total of sixty-eight cases, or 90.67 per cent. These results from laminectomy alone compare favorably with the results in cases reported by Ghormley and associates; Smith, Deery, and Hagman; and Barr, in which the combined operation was performed.

In 1946, Friberg and Hirsch reported a similar survey of later operative results after simple removal of the protruded nucleus pulposus. They re-examined forty-seven patients, five years or more after operation. Thirty-seven patients had proved protrusion; relief from sciatic pain was obtained in thirty-one, or 83.8 per cent. of the patients, and

TABLE II

SUMMARY OF GOOD RESULTS

Results	No. of Cases	Per cent.
Excellent	32	42.67
Satisfactory	30	40.00
Recurrent (excellent and satisfactory results before and after recurrence)	6	8.00
Total	68	90.67

relief from back pain in twenty-six, or 70 per cent. They have consistently avoided performing fusion in connection with extirpation because: "The patient wanting above all to get rid of the severe sciatic pains, we have considered the fusion as an unnecessarily great operation with regard to the considerably longer postoperative treatment, and we have reserved the stabilizing operation for those patients operated for prolapse which have complained of low back pains causing invalidity."

If so many good results can be secured by laminectomy alone, the necessity of the combined operation may be doubted. Those who advocate the combined procedure believe that recurrences may be prevented by fusion and that disabling pain in the back, resulting from hypertrophic changes and progressive narrowing of the involved disc, will not occur. Love, however, has reported that protrusion of the nucleus pulposus *has recurred* anterior to the spine graft in two cases in which successful fusion had been performed, and that later protrusions above the level of fusion have been observed. He noted recurrence in only 5 per cent. of a series of 987 patients, traced by questionnaire or interview.

The incidence of recurrence from three to seven years after the first operation is 8 per cent. in our series, but without exception, these patients were relieved of pain in the back and lower limb for varying periods of time before and after the second operation (Table III). It is conceivable that stabilization of the affected segments of the spine may reduce the percentage of recurrences, but it must be remembered that the statistics of Bosworth and others on fusion of the spine show that failure of fusion occurs in 15 to 25 per cent. of cases. If the low incidence of recurrences (Love, 5 per cent.; our series, 8 per cent.) is weighed against the possibility of failure of fusion in 15 to 25 per cent. of the cases, one may question whether fusion is required, especially since it is known that recurrences may take place even after successful fusion.

TABLE III

ANALYSIS OF SIX RECURRENT CASES *

Case No.	Period of Relief Prior to Second Operation (*Months*)	Period of Relief after Second Operation (*Months*)
1	54	27
2	66	16
3	32	62
4	12	40
5	25	10
6	36	1
Average	37.5	26

* Pain in back and lower extremity relieved in all cases, except for short period before second operation.

TABLE IV

ANALYSIS OF ANOMALIES IN TWENTY-SEVEN CASES

Anomaly	No. of Case
Spondylolisthesis or spondylolysis	5
Sacralized process	9
Spina bifida	4
Asymmetrical facets	9
Total	27 (36%

TABLE V

CORRELATION OF ANOMALIES WITH FUNCTIONAL RESULT

Functional Result	Anomaly Present	
	No.	Per cent.
Excellent (32 cases)	11	34.37
Satisfactory (30 cases)	13	43.33
Unsatisfactory (13 cases)	3	23.07

Of the seven unsatisfactory cases (other than recurrences), satisfactory results we finally secured in three,—in two by means of spine fusion and in one by rhizotomy. O patient, who was relieved by decompression, subsequently became a narcotic addict. Th remaining three patients have definite neuropsychiatric symptoms. It is strongly suspecte that two of these have other protrusions of the discs which will eventually require remova

Congenital anomalies, which occur in the lumbosacral region in approximately 1 per cent. of all the patients, are thought to predispose to instability of the spine with co sequent degeneration of the disc. It has been assumed that this instability would contin or increase after an operation for removal of a protruded nucleus pulposus, and cause na rowing of the disc with hypertrophic changes, accompanied by disabling pain in the bac With these thoughts in mind, we have reviewed the roentgenograms of all cases in th series, have determined the incidence of anomalies, and have correlated these finding with the functional results.

One or more anomalies existed in twenty-seven patients, or 36 per cent. of all the cas (Table IV), but the incidence was much less in the unsatisfactory group (including th recurrences) than in those with good results (Table V). One may, therefore, questio whether or not anomalies contribute to the unsatisfactory results, following simple lam nectomy for removal of a protruded nucleus pulposus.

TABLE VI

POSTOPERATIVE CHANGES *

Results	No. of Cases	Per cen
No apparent change (3 to 7 years)	23	30.67
Hypertrophic spurs, sclerosis only	6	8.00
Disc narrowing only	13	17.33
Combined narrowing and hypertrophic changes	33	44.00
Total	75	100.00

* One or more changes were present in 52 cases (69.3%).

Hypertrophic changes, narrowing of the intervertebral disc (Figs. 1-A and 1-B), or a combination of both conditions, occurred in 69.3 per cent. of the cases in our series (Table VI). The extent of such changes varied greatly.

These postoperative changes occur more frequently among those patients with good results than among those with unsatisfactory results (Table VII). Furthermore, there is no relationship between those patients with advanced hypertrophic changes and the functional results. In several cases the most advanced hypertrophic changes occurred among patients with excellent results. These findings were surprising, and seemed to contradict the supposedly logical deduction that hypertrophic changes of the vertebral bodies and facets are a cause of disabling pain in the back. The authors wonder if the more serious and acute episodes of pain in the back are not caused by bulging of the nucleus pulposus against the annulus fibrosus and posterior longitudinal ligaments. Roofe has demonstrated large numbers of nerve endings in the posterior longitudinal ligament, and Ehrenhaft has found evidence of them in the annulus fibrosus. Echols has repeatedly

FIG. 1-A

Roentgenograms of patient, forty-five years of age, showing moderate narrowing of fourth disc and minimal hypertrophic changes, prior to removal of protruded nucleus pulposus on September 19, 1942.

FIG. 1-B

Roentgenograms showing increased narrowing of disc and hypertrophic changes, five years later. Patient returned to work within three months after operation and has never had significant complaints referable to back. Result was rated excellent.

TABLE VII

CORRELATION OF POSTOPERATIVE CHANGES WITH FUNCTIONAL RESULTS

Functional Result	One or Both Present	
	No.	Per cent.
Excellent (32 cases)	25	78.13
Satisfactory (30 cases)	17	56.67
Unsatisfactory (13 cases)	10	76.92

demonstrated, at operations under local anaesthesia, that pressure against the annuli fibrosus and posterior longitudinal ligaments reproduces the pain in the back, of whi the patient has complained. Moreover, clinical observation has shown that, as the typic disc syndrome develops, pain in the back is predominant until actual protrusion occur then sciatic pain becomes dominant. This indicates that after rupture of the annuli fibrosus and ligament has occurred, tension is relieved and the pain in the back disappea or is greatly diminished. In view of these observations, it seems likely that too mu stress has been placed on the development of hypertrophic changes as the major cause f disabling pain in the back.

After rupture of the ligament with protrusion of the nucleus has occurred and the pr truded portion of the nucleus has been removed, narrowing, with or without hypertroph changes, occurs in 69.3 per cent. of the cases, but the process continues without produci significant pain. Whenever attacks of pain recur, it seems probable that they are associate with bulging of the nucleus at the same or another level, rather than that they are due hypertrophic arthritis.

A careful evaluation of the thirty patients in the *satisfactory* group revealed th with adequate postoperative treatment, excellent results might have been obtained i approximately 63 per cent. of the patients. It was found that although the symptoms pr duced by the protruded nucleus pulposus were relieved, treatment of the general physic and mental state had often been neglected.

Prolonged severe pain and chronic disability diminish a patient's confidence in h ability to recover, and a fear of the pain frequently develops, which may persist for year Consequently, these patients had become sedentary, so that stiffness persisted and so ness and fatigue appeared after any unusual activity. The patients attributed the symptoms to the original disabilities rather than to the natural sequence of events.

Obesity, poor posture, stiffness, and general weakness were the basis of the usu complaints in this group. More specifically, there were residual limitation of motio of the spine, weakness of the abdominal muscles, mild contraction of the hamstring an hip-flexor muscles, and frequently weakness of the extremity originally affected.

As a result of these observations, stricter supervision of these patients during convalescence has been inaugurated, with emphasis on:

1. Weight control;
2. A regulated increase in activity, compatible with the patient's age and general condition;
3. Special exercises to strengthen and increase the suppleness of the involved muscles;
4. An explanation to the patient of the cause of the residual pain;
5. Reassurance. *This is perhaps the most important and may obviate the necessity for other measures.*

SUMMARY

The results of this study in proved cases of protrusion of the nucleus, three to seven

years after laminectomy without fusion, suggest the following answers to the questions propounded earlier in this discussion:

1. Excellent and satisfactory results can be obtained in as high a percentage of cases by laminectomy alone as by the combined operation.

2. Hypertrophic changes of variable degree, with or without narrowing of the disc, occurred in 69.3 per cent. of the cases studied.

3. Functional end results do not correlate with or depend upon the presence or extent of such postoperative changes.

4. The end results are not significantly related to the existence of anomalies.

5. Recurrences took place in 8 per cent. of the cases studied, but did not seem to relate to the presence of anomalies or postoperative narrowing of the disc and hypertrophic changes. The number of recurrences was small, and there was nothing in the preoperative history and findings which indicated that protrusion would occur again at the same or another level.

Most of the unsatisfactory results (other than recurrence of protruded disc) were such that spine fusion would not have improved them.

CONCLUSION

There are no criteria for spine fusion following removal of a protruded nucleus pulposus.

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DISCUSSION

Dr. Raymond E. Lenhard, Baltimore, Maryland: The papers presented by Dr. Holscher and Dr. Caldwell are confined to a small but important phase of low-back care.

I have had no experience with the unfortunate complication described by Dr. Holscher, nor do I know of any such occurrence in Baltimore. As far as I can learn, the neurosurgeons who perform most of the disc removals in Baltimore use a curette instead of a pituitary rongeur, because of the danger of penetrating the anterior ligament in attempting a complete removal of the annulus. The complication described by Dr. Holscher resulted, happily enough, in an arteriovenous aneurysm instead of a rupture of the large vessel.

Dr. Caldwell makes it clear that supervision of the treatment by an orthopaedic surgeon before and after operation is important; I think it is largely because of this fact that he has been able to report such a high percentage of good results. His patients have been given a reasonable trial of conservative treatment, have been carefully selected for operation, and have had adequate postoperative care.

It is my feeling that the orthopaedic surgeon cannot escape the problem of low-back pain. In 1945, I surveyed, by examination of the patients and by questionnaire, 513 cases in which operation had been performed by a neurosurgeon. The patients' backs were not fused. The results were good in 64 per cent.; the

patients were able to carry on their normal activities with no symptoms, or with slight stiffness or weaknes that was not disabling. Twenty per cent. were improved, but had symptoms which restricted their activitie at times. I feel reasonably certain that the percentage of good results could have been higher, had the patient been more carefully selected for operation, or had they been more adequately treated from an orthopaedi standpoint after operation.

Fourteen per cent. of the patients had had removal of the protruded portion of the disc only: the other had had removal of the entire disc or of multiple discs. The 14 per cent. had results that were as good as, o slightly better than, the others.

I have had no personal experience with an analysis of the results of the combined operation, but I hav believed that one should expect better results from the combined operation in selected cases. I have suppose that congenital anomalies, narrowed interspaces, localized arthritis, spondylolisthesis, and work potentialitie should influence one to advise fusion after disc removal. It is enlightening to hear Dr. Caldwell's finding that some of these factors are not necessarily indications for fusion. More analyses similar to his will help i deciding the need for fusion.

On the whole, I try to be conservative in the treatment of patients with low-back problems. The benefit of conservative treatment should be exhausted before exploration is done; and the necessity for fusion shoul be carefully considered.

DR. JAMES W. SCHUMATE, SAN FRANCISCO, CALIFORNIA: Dr. Holscher has demonstrated the ease wit which serious vascular injuries can take place in the removal of ruptured intervertebral discs; it is surprisin that such complications have not happened more frequently. This is especially true when one considers th great number of disc operations now being performed and the enthusiasm with which some surgeons attemp to remove the entire intervertebral disc.

Recently, at Stanford Hospital in San Francisco, a careful attempt was made to remove the entire dis in several consecutive cases. In no case, however, did the disc tissue removed weigh more than one-third a much as a normal disc. The value of removing as much disc tissue as possible is debatable, and the dange have been dramatically demonstrated by Dr. Holscher.

Dr. Caldwell's paper was well written and ably presented, yet it will probably meet with disagreemen Of the 151 patients upon whom operations were performed, there were thirty-four in whom ruptured dis were not found at the time of operation. In what other orthopaedic condition would a 20 per cent. error diagnosis be condoned? Dr. Caldwell has admitted that Ghormley and Smith indicate a higher percentage good results by the combined operation of disc removal and spine fusion, but he states that this reasoni has been given a rude jolt by an insurance company which reported good results in only 14 to 40 per cent. the cases. I would like to ask what percentage of Dr. Caldwell's series were insurance cases.

I took the liberty a few days ago of calling the State Compensation Insurance Fund in California: an one of their Medical Directors was kind enough to review 200 cases in which disc operations had been pe formed. He reported 29 per cent. excellent results, 23 per cent. good results, 36 per cent. fair results, and 1 per cent. poor results. I doubt, however, that orthopaedic surgeons could consider his fair results as approac ing satisfaction. These patients were unable to return to their usual occupation, had considerable pain, an were given a permanent disability rating for a moderately severe back condition.

In 28 per cent. of these 200 cases, fusion was done; the results were good to excellent in 50 per cent., fa in 26 per cent., and poor in 24 per cent. In many of these cases, however, fusion was done after a poor resu had been obtained from the removal of a ruptured intervertebral disc.

I have had personal contact with four leading neurosurgeons, who perform practically all of the dis operations in the San Francisco Bay area. Two of these men estimated that the combined procedure wa carried out in 50 per cent. of 900 cases; one estimated 10 per cent. of 500 cases; and one estimated 1 per cen of 400 cases. None of these men, I am sure, had any idea of the number of spine stabilizations performed aft the case had been returned to the orthopaedic surgeon.

I have made no mention of my own cases. By the use of bilateral leg traction and rotatory manipulatio under anaesthesia, Merrill Mensor and I have secured 80 per cent. of satisfactory results in a relatively larg series of cases. Less than 10 per cent. of our series have had operation. I was tremendously interested in th remarks made at the instructional course on low-back pain by H. Osmond-Clarke of London. He stated tha no more than 5 to 10 per cent. of his patients with disc lesions were operated upon. Later, in a private con versation, he said that conservative treatment produced satisfactory results in approximately 80 per cent of the cases. His figures are comparable with mine, although I believe that, because of immediate relief from pain following manipulations, our cases have a much shorter period of convalescence.

In closing the course on low-back pain, Dr. Joseph S. Barr predicted that, in the near future, *all* patients operated upon for the removal of a ruptured intervertebral disc would have the spine stabilized. Dr. Caldwell's conclusion was equally dramatic: "There are no criteria for spine fusion following removal of a protruded nucleus pulposus". Such widely divergent views, expressed by capable men, constitute conclusive evidence of a faulty knowledge of the subject. The answer undoubtedly lies somewhere between these two extremes.

It is my firm conviction that, before Dr. Barr's prediction comes true, and as a result of improved manipulative technique and other conservative treatment, the operation for the removal of the ruptured intervertebral disc will have been discarded.

Dr. Joseph S. Barr, Boston, Massachusetts: I wish first to extend my personal and sincere appreciation to Dr. Holscher for his paper. He has called the attention of this large group to a disaster which may occur in a relatively simple surgical procedure. I know of one such case which he did not mention; I am sure the others are well-documented cases.

Dr. Caldwell has reviewed a series of cases of ruptured intervertebral disc, operated upon at the Ochsner Clinic without spine fusion; and he has attempted to compare the results with similar series of cases reported from other clinics. His first conclusion is that excellent and satisfactory results can be obtained in as high a percentage by laminectomy alone as by the combined operation. It is difficult to compare series from different clinics, and particularly dangerous when the same criteria are not used. In our series, reported last year, we deliberately discarded the classification of excellent, good, and unsatisfactory; and we did not use those terms in the paper. We had each of our patients fill out a questionnaire in which we asked for the following specific information:

1. Do you have back pain?
2. Does your back feel strong?
3. Can you stoop, twist, and lift without back discomfort?

A total of 234 such questionnaires were returned, and 95 of these patients came in for x-ray and clinical examination. Comparing 132 cases treated in our hospital without fusion with 102 in which fusion had been done, we found that the percentage of fused cases without symptoms was definitely higher than for the unfused cases. I doubt the advisability of comparing our cases with fusion and Dr. Caldwell's cases without fusion, especially since he apparently did not ask the same questions we did.

Neurosurgeons in certain clinics in this country removed ruptured intervertebral discs without spine fusion. If they had been satisfied with the results, they would have given little time to consideration of spine fusion. Yet, in the majority of good clinics, fusion versus non-fusion is a very live question. In most clinics, there is a trend toward the combined operation.

There is opportunity for improvement in the surgical technique of the combined operation, but great strides have already been made and it is now essentially as safe as disc removal alone. Convalescence is not unduly prolonged, and in our hands the percentage of completely symptom-free cases is higher than in the series without fusion. One might ask why not wait and fuse at a second operation, if the patient has symptoms? These patients have usually had months or years of disability before operation. They have had a major operation for relief of their sciatic pain. After convalescence, many of them still have some back pain. They have learned to lead a life of somewhat restricted activity. The pain is usually endurable; their finances may have been exhausted, and the patient may refuse to have another major operation for pain which is less than completely incapacitating. I have seen a number of cases in which the psychological impact of repeated surgery and long-continued disability has produced chronic, confirmed invalidism.

I agree that end results are not related to the existence of anomalies. Dr. Caldwell's figures seem to show that we are much better off if we have hypertrophic spurs on our vertebrae than if we don't. I can only say that such spurs are commonly considered to be an integral part of the aging process, and that none of us like to age prematurely.

In Dr. Caldwell's seventy-five cases with end results, only 42 per cent. showed excellent results. His conclusion that "there are no criteria for spine fusion following removal of a protruded nucleus pulposus" reflects a complacent attitude, incompatible with our continued struggle to improve our work.

Dr. William B. Sheppard (closing): I wish to thank the discussors. They were much kinder than I expected them to be.

Dr. Barr stated that we did not ask our patients the questions he asked in his questionnaire. We did not include those patients to whom we sent questionnaires but who did not have follow-up examinations, because we believed that these cases were not absolutely reliable for statistical purposes. In many instances, it was difficult to obtain a comprehensive answer, even to direct questioning. For example, one woman's answer to direct questioning was: "Yes, I have back pain every day,—every time I lean over". Further questioning yielded the information that, after stooping over a tub of washing, she experienced transitory pain when she straightened up. It would not be fair to include her in the group with unsatisfactory results, and yet she could not be considered as having an excellent result.

Dr. Schumate requested information on the number of patients who had compensation or insurance. Although we did not compile statistics, we did question the patients in regard to the kind of insurance they had and whether or not they were still receiving insurance. We believe that the manner in which the insurance is received is the important factor in determining the rapidity of recovery. One of the patients in whom the result was unsatisfactory is still receiving $100 a month as compensation. However, there were relatively few compensation cases in this series.

Dr. Lenhard called attention to the careful orthopaedic supervision before and after the operation. It is true that every patient had careful orthopaedic treatment before operation; but afterward, unfortunately, many of them were neglected. For this reason, we now request that the patients return to the orthopaedic surgeon for strict supervision during convalescence.

A RAPID METHOD OF CORRECTING DEFORMITY IN SCOLIOSIS PRELIMINARY TO FUSION *

BY VINCENT A. SCUDESE, M.D., NEWARK, NEW JERSEY

From the Hospital for Crippled Children†, Newark

One of the difficult problems in the treatment of scoliosis has been to correct mechanically the deformity in those cases that are not amenable to exercise and physiotherapy A rapid and adequate method of correction of the deformity, preliminary to fusion, is suggested. This method has been in use for the past year and a half. The principle is to correct the deformity first by means of the lateral flexion apparatus, and then to apply a retaining plaster cast which may be windowed for any operative work undertaken later. The procedure requires about one-half hour.

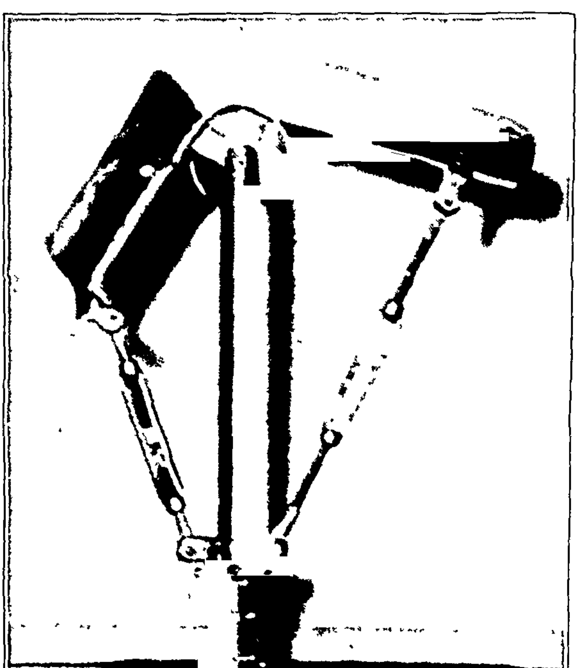

FIG. 1

Lateral view of lateral flexion apparatus.

The correction is obtained on the lateral flexion apparatus (Fig. 1), which is constructed with two adjustable turnbuckle troughs, firmly hinged to a bar which can fit into the pelvic rest of a fracture table. It may be used for either children or adults. The troughs, one shorter than the other, are adjusted so that when the patient is placed on his side in them, he may drop into a position of practically maximum correction with no tendency to fall off the apparatus.

The patient is placed on the apparatus with the apex of his curve directly over the apex of the apparatus. The apex of his curve then acts as a fulcrum; and the body weight, extending on each side of the apex, acts as a force that allows the scoliotic curve to conform to the apparatus, which is curved in the opposite direction. Thus the force of correction is great and must be supplemented by the lever-arm effect of that part of the body weight which acts at a distance from the fulcrum. Roentgenograms, taken of the patient on the apparatus at this time, usually show good correction of the curvature. This may be made maximal by additional downward pressure, exerted on the upper and lower ends of the body by assistants (Fig. 2).

The lateral flexion apparatus eliminates many of the difficulties encountered in the

* Read at the Annual Meeting of the New Jersey Orthopaedic Society, October 11, 1947.

† Service of Toufick Nicola, M.D.

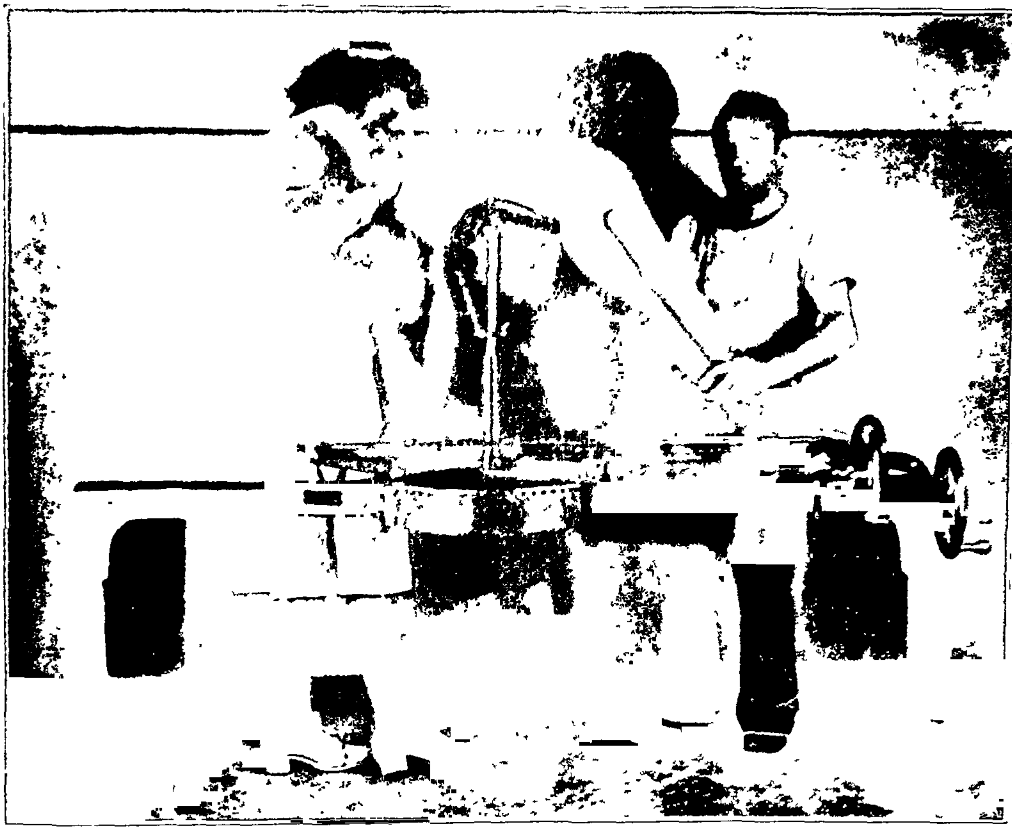

FIG. 2

Maximal correction of curvature may be obtained by downward pressure, exerted at the upper and lower ends of body.

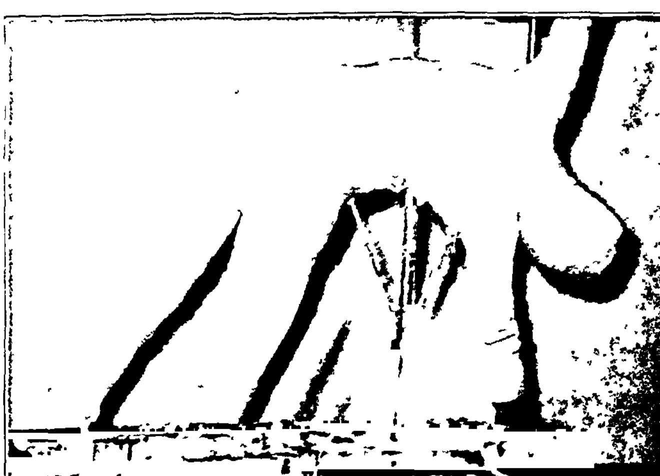

FIG. 3

Shows patient with corrective plaster cast, as well as apparatus and fracture table.

conventional methods of correction. It permits easy and rapid correction, with more derotation of the spine and reduction of the razor-back deformity.

The essentials in the management of a case of scoliosis by this rapid method of correction consist in:

1. Correct positioning of the patient on the apparatus;

2. Roentgenographic determination of the amount of correction;

3. Immediate application of a plaster cast (Fig. 3), extending from head to knee on the convex side of the body, from head to greater trochanter on the concave side, and covering both arms to the elbows.

NOTE: Appreciation is extended to Toufick Nicola, M.D., for his kindness, advice, and valuable suggestions in the preparation of this work.

BONE DISTURBANCES IN INJURIES TO THE SPINAL CORD AND CAUDA EQUINA (PARAPLEGIA)

THEIR PREVENTION BY AMBULATION *†

BY ARTHUR S. ABRAMSON, M.D., BRONX, NEW YORK

From the Veterans Administration Hospital, Bronx

Certain bone disturbances occur with great frequency in injuries to the nerve contents of the vertebral canal. Some of these and their sequelae are often severe and crippling and, on occasion, may even be capable of shortening the life span.

Among the many disturbances which occur in the skeleton in paraplegia are bone atrophy; soft-tissue ossifications [8]; bone erosions, usually of the ischial tuberosities and trochanters [4]; osteomyelitis in the region of decubitus ulcers; sacro-iliac fusion; and pathological fractures. The tenacious preservation of the joint surfaces is remarkable [4]. Arthropathies occur rarely, instead of with the frequency that would be expected, considering the nerve lesion and the anaesthesia. Perhaps, as Heilbrun and Kuhn suggest, more time must elapse before we can be sure that the wear and tear of activity will not produce joint destruction.

Of this group of bone disturbances, atrophy and soft-tissue ossifications are the most important, because of the disabilities they may produce, and because of the frequency o their occurrence.

Bone Atrophy

The loss of bone density in motor paralysis is well known [3]. The phenomenon o atrophy is commonly observed in paraplegia, where, with the passage of time, the bone below the level of the lesion undergo a greater or lesser degree of decalcification (Figs 1 and 2).

In differentiating osteoporosis (used in the strict sense of disuse atrophy) from othe conditions producing bone atrophy, the outstanding criterion is that the blood serum calcium, phosphorus, and phosphatase are normal [1]. In his series, Soule showed this to b true. In osteoporosis, *there is no disturbance of the deposition of calcium into the bon matrix*; but the laying down of the bone matrix itself is deficient [1]. Jaffe [4], reporting on a biopsy specimen taken from the eroded trochanteric area of one of the cases reported by Heilbrun and Kuhn, said that there was progressive atrophy and resorption of the osseous tissue proper. Unfortunately, there was evidence of a good deal of inflammation in th specimen, because there had been a decubitus ulcer in the region. However, this may b histological evidence of osteoporosis in paraplegia. It would seem, then, that disuse was a major factor, if not the only factor, in the production of atrophy in paraplegia.

Urinary Calculi

In disuse atrophy, the calcium output in the urine increases steadily for a period of about thirty days; then it maintains a high level, presumably until function again takes place. This phenomenon has been observed, although to a lesser degree, in healthy individuals who have been put to bed with plaster fixation. Howard is of the opinion that the excess quantities of calcium thus appearing in the urine must be a major factor in the

* Read before the New York Society of Physical Medicine at the New York Academy of Medicine, New York, November 5, 1947.


FIG. 1


FIG. 2

Bone atrophy, observed as a result of non-ambulation, in two cases of spastic paraplegia of over two years' duration with the lesions at the mid-thoracic level. Patient shown in Fig. 1 walked, but patient shown in Fig. 2 did not. Note also the soft-tissue ossification in the hip region in Fig. 2.

production of stones in these individuals. The stones are invariably calcium phosphate or carbonate in character [5].

Soft-Tissue Ossifications

These ossifications have also been called "myositis ossificans circumscripta neurotica" [7], "para-osteo-arthropathies" [4], and "neurogenic ossifying fibromyopathies" [8]. They may occur in a large variety of neurological diseases [6, 8]. Soft-tissue ossifications in paraplegia occurred in a third of the cases studied by Soule, and in Meyer's six cases [7]. The less frequent incidences reported by some writers may be due to the lack of complete roentgenographic studies.

Ossifications can occur in almost all soft tissue, and they appear most frequently in relationship to the larger joints, especially the hip. In cervical lesions, they may occur around the shoulder (Fig. 3); but they never occur above the level of the lesion. It is probable that, in the first phase, amorphous masses of calcium are laid down in the muscles. tendons, ligaments, and capsules. Then. true osseous tissue commences to form [4, 8]. These ossifications may occur as early as twenty days after injury [2]. They may be multiple. and may or may not be connected with the periosteum. Their formation is progressive to a certain point where they become stable, after which no new masses form and no old masses increase in size. In other neurological conditions, they progress as long as the lesion progresses. In this respect, they differ from traumatic myositis ossificans, the course of which is consistently regressive after the initial calcification. There is apparently no relationship to local trauma or decubitus ulceration. and the size and distribution of the ossifications do not seem to differ with the site and severity of the lesion [8]. The ossifications may be massive enough to surround the joint entirely, rendering it completely immobile. although lesser degrees of formation also may interfere with joint motion. Most important of all is the fact that many of the soft-tissue ossifications occur in conjunction with bone atrophy [4, 7, 8].

The intimate association of osteoporosis with ossifications makes it more than probable that the excessive calcium mobilization from the bones is one of the predisposing factors in the production of ossifications. The fact that they occur only in paralyzed por-

FIG. 3

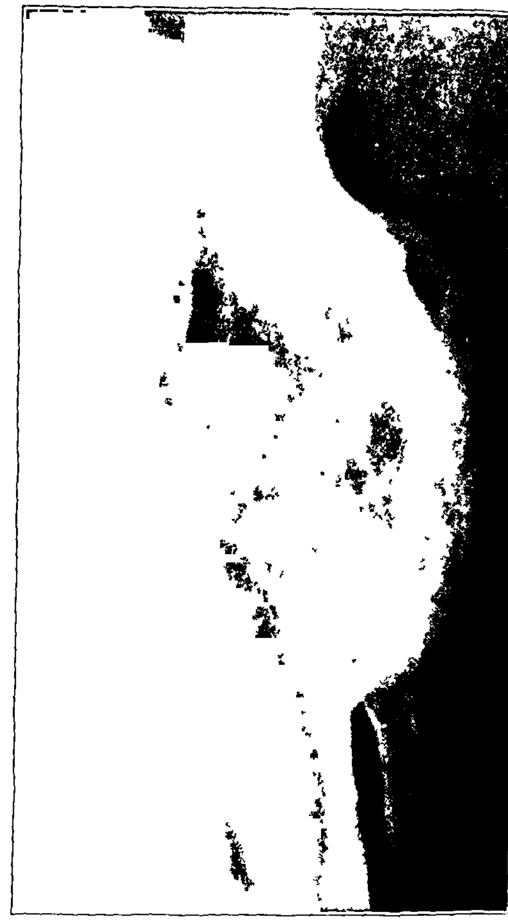

FIG. 4

Fig. 3: Bone atrophy and soft-tissue ossifications occurring in the shoulder, in a case of lesion of the cervical cord. The ossifications never occur above the level of the lesion.

Fig. 4: A case of non-ambulatory paraplegia. A soft-tissue ossification has fused the posterior aspect of the knee joint. This limb bears weight only when the patient moves from bed to chair or from chair to automobile. Despite the intense atrophy elsewhere, the fusion has created a weight-bearing line along the posterior cortices of the tibia and femur. As a result, these cortices are dense.

tions of the body, and in neurological diseases, is strong presumptive evidence that other factors also are active in their formation.

This attempt to link the triad of osteoporosis, urinary-stone formation, and soft-tissue ossifications leads to the postulate that, if osteoporosis is prevented, stone formation and metastatic ossifications also would be prevented, or at least reduced to a minimum.

Howard states: "We have as yet no true idea of the circumstances or stimuli which induce bone cells to make new bone or what stimuli induce bone resorption. . . . Efforts should be made to determine the fundamental stimulus which is active in bone resorption in these patients. If it could be found, we might eliminate it and hence prevent atrophy of disuse. . . . Should such fundamental information become available, we might be able to eliminate the problem of stone formation in these patients. . . ."

There are many clues in the literature as to the nature of this stimulus, although its exact mechanism is as yet unknown. In a monograph written in 1920, Jansen made an attempt to disprove Wolff's law of bone transformation. The law states: "Wheresoever stresses of pressure and tension are caused in a bone, be it by pressing forces or by pulling forces, formation of bone takes place". This was supposedly proved by the fact that bone trajectories crossed at right angles. This premise was accepted for many years, but claims gradually appeared in the literature that tension was not a bone-forming stimulus, but only pressure played this role. Jansen, after a careful study of the trabeculations of bone, came to the following three conclusions:

1. Elements of cancellous tissue do not always cross at right angles, and therefore do not coincide with the directions of greatest tension and greatest pressure.

2. Cancellous tissue does not show bone in any part that has to resist tension only.

3. Resisting bone elements do not undergo thickening on an increase in tension, as is the case on an increase of pressure.

Others have claimed that where tension is the primary force to which the bone is subjected, it is the stimulus for the production of bone; this is also true of pressure, where pressure is the primary force [9]. The subject may be controversial, but one fact stands out clearly: Pressure, in paralyzed lower extremities, is the stimulus for bone formation by reason of the fact that pressure is the primary force (Fig. 4).

Weinmann and Sicher state: "The pressure-bearing bones or parts of bones are likewise reinforced by the production of new bone, a fact which is less obvious and therefore often unrecognized".

It is commonly accepted that the metabolism of calcium in relationship to bone is dynamic, and that bone will be absorbed if left alone. There is a negative calcium as well as nitrogen balance in injuries of the spinal cord. Since the fundamental disturbance is in the laying down of the bone matrix, pressure is the stimulus for its formation. In the normal bone, as much or more calcium is being laid down as is being removed. In paraplegia, more calcium is being removed than is being laid down, due to the deficient matrix formation.

Therefore, longitudinal pressure (or pressure along the axes of the lower extremities) should be used as a therapeutic agent to prevent disuse atrophy, and, secondarily, to minimize its sequelae. Weinmann and Sicher state that long-continued pressure or stresses beyond the physiological limits of the bone may produce bone atrophy instead of condensation. Since ambulation by means of crutches and braces is a form of intermittent pressure, it is as much within the physiological limits of stress as is normal walking. The minimum amount of ambulation necessary to prevent bone disturbances has not been determined, but there is some evidence to the effect that ambulation must be started early, and that it must be considerable. Neither has the effect of ambulation on ossifications which have already formed been determined, but Soule's findings indicate the possibility that regression may occur. He reported three cases of regression; in at least one of these cases, regression started after ambulation had commenced. It is logical to assume that the atrophy is reversible, and that it should be corrected as soon as pressure again produces bone matrix.

Statistical Evidence

In this study, only those patients were selected who had complete lesions, or at least lesions which did not permit ambulation without braces or crutches. The majority of the patients led a wheel-chair existence.

In accumulating statistics to support this view, considerable difficulty was encountered. It is an unfortunate fact that, despite every incentive, paraplegics—in this group at any rate—have an aversion to ambulation. For the sake of making the distinction between ambulation and non-ambulation clear-cut, the criterion for ambulation was arbitrarily set as at least two years of walking for an hour or more nearly every day. This criterion was chosen because it was discovered that this was the maximum amount of ambulation done, in this series. It was feared that with any other criterion, interpretation would be difficult and dangerous.

Only eight cases which fit into the ambulation category were found. Forty-eight patients could be considered almost completely non-ambulatory, for about two or three years after injury. From one to fourteen urinary calculi each developed in twenty-one of these forty-eight patients. Thirty of these patients were examined roentgenographically, and twenty-five were found to have osteoporosis, varying in degree from mild to severe. Soule reported a lesser incidence of atrophy in his series, but his cases were of shorter duration, and some of his patients had a degree of recovery of motion which may have rendered them partially ambulatory.

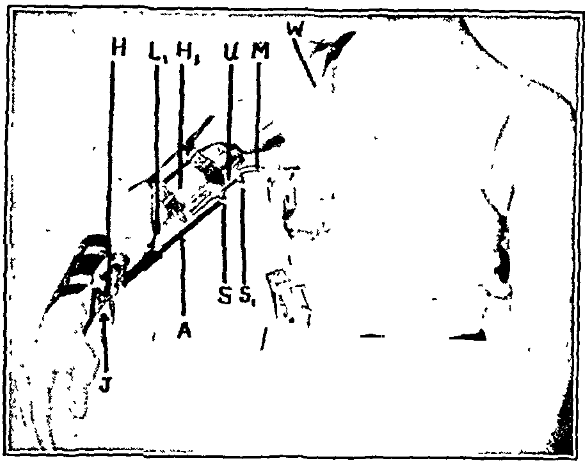

Fig. 1

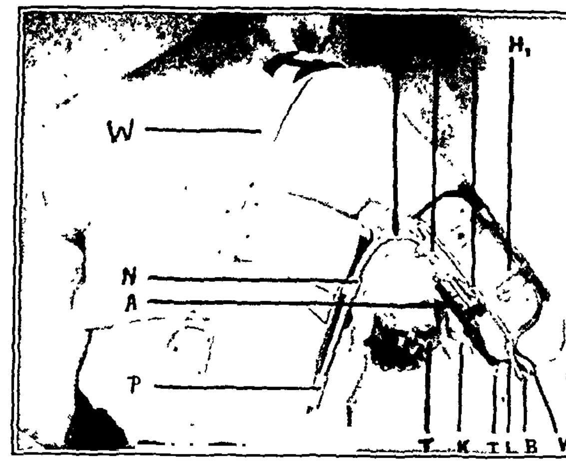

Fig. 2

Brace No. 1, viewed from front and back.

and the normal muscle or group of muscles. The antagonist can move the limb normally, and the spring will return it in the opposite direction when the normal muscle is relaxed. Such a spring must be of just the right strength to "float" or balance the part between it and the normal or uninjured muscle.

Two braces have been made. The first one gave limited motion. As muscle function returned, changes were made in the brace to allow increased movements of the arm. Brace No. 1 (Figs. 1 and 2) was made in February 1943. The essential purposes and features of this appliance were as follows: (1) It served to maintain the arm at a convenient height in abduction (45 degrees), so that the hand could function usefully. (2) Since the external rotators were useless at first, the appliance had also to support the forearm at a convenient level for working and keep it from dropping (rotation of arm inward). (3) Flexion of the forearm was provided by an elbow joint and a spring (the triceps extends the arm, the spring pulls it back). (4) A support had to be provided for the hand, as the extensors of the wrist were at first too weak to prevent wrist-drop which might result from fatigue. This support was removable and was worn only when the hand was not in use, as when the individual was walking or sitting. (5) Forward and backward action of the arm was permitted.

As time passed, the pectoralis major, which was not badly damaged, was able to produce strong forward motion; the infraspinatus and teres major became strong enough to produce backward motion, but not until the end of twenty months did they produce external rotation.

Any sturdy body brace or jacket will suffice to support the arm brace. At first duralumin was used, but this proved to be unsatisfactory; and steel had to be used in the body brace to withstand the strain of the functioning arm, acting as a lever against the body. It is quite evident that stronger body braces are necessary when the arm is in use than when it is held quietly. With the brace described here, the patient is able to drive an automobile and to enjoy gardening, as well as to resume the active practice of general surgery.

Arm Brace No. 1

Figures 1 and 2 illustrate the first brace made, which incorporates the five features mentioned in a preceding paragraph.

1. *To Maintain the Arm in Abduction*

A three-eighths-inch rod of cold rolled steel of sufficient length (Figs. 1,*M* and 2,*M*) is bent at a 45-degree angle. The longer end rotates in a tube (*N*) and a well (*P*), fixed in the body cast; a shorter end holds the arm cuff (H_1), which is made of duralumin and lined with leather. The cuff is riveted to the three-sixteenths-inch steel bar (L_1); this is seven-

eighths of an inch wide and long enough to reach to the elbow, with steel rivets to withstand the strain. The steel bar is, in turn, riveted to a steel block (U), two inches by five-eighths of an inch by one inch, with a half-inch flange on each end to hold the rivets. The block is bored to take the three-eighths-inch rod (M). The undersurface of the arm end of this rod is filed flat, so that the two screws (Fig. 1, S and S_1), which are threaded into the block (U), will impinge upon this flat surface, preventing rotation of the arm cuff. The lower of the two screws is for fixation of the upper end of the biceps spring (A).

2. *To Support the Forearm*

The steel arm bar (L_1) is articulated with the forearm steel bar (L) (Figs. 2 and 3). This is made of material like that of L_1, tapers to three-quarters of an inch in width, and is beveled to fit the supporting trough (K) which carries the forearm cuff (H). The bars for the arm and forearm are bent downward slightly as they approach the elbow joint, to give room for the medial malleolus of the humerus. Further skin protection is added by a tongue of leather, extending downward from the arm cuff and padded with a piece of sponge rubber (Fig. 2,V).

The forearm cuff is pivoted (Fig. 1,J) to the trough (K) (Figs. 2 and 3). Theoretically, as the forearm is extended, the forearm bar should follow in a parallel line; but, because the humerus is surrounded by soft tissue and therefore cannot be held firmly in one place, the elbow joint moves forward and backward. To allow for this excess motion, the forearm cuff is pivoted at J, and more readily follows the axis of the forearm as it is extended or flexed.

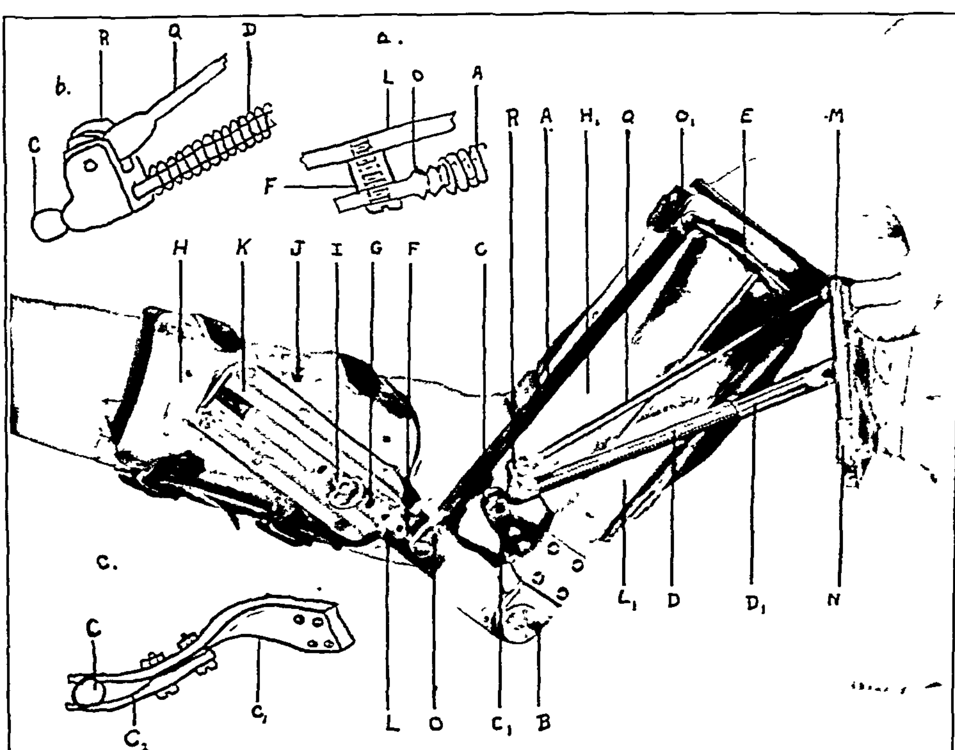

FIG. 3

Brace No. 2 viewed from front, arm rotated outward to show construction.
Inset *a:* Spring end-fitting, O, which revolves around shoulder of stud, F.
Inset *b:* Steel ball (C), brazed to milled fitting and quenched.
Inset *c:* Leverage arm (C_1) and retaining plate (C_2) allow ball to rotate between them, forming universal joint.

3. *To Produce Flexion of the Elbow*

The brace elbow joint (*B*) is a simple joint, with a rather large pivot and a stop which prevents the forearm from reaching 180 degrees in extension. This stop is necessary, for, if the forearm were allowed to extend to a straight line, the spring (*A*) would be projected beyond the line of pivot and would not, therefore, bend the elbow in returning the forearm to a flexed position.

The spring (Figs. 1,*A* and 2,*A*), an ordinary screen-door spring, reaches from the lower fixation screw (*S*) to the adjustable thumb screw (*I*). Spring end-fittings (Fig. 3, Inset *a*) were devised to keep the spring pulling constantly in a straight line and revolving around the points of fixation (*F* and O_t).

After Brace No. 1 had been used for several months, the flexion of the elbow due to returning strength in the muscles made it possible to change the angle of the spring with forearm bar (Fig. 3, *L*). *L* is supplied with several threaded holes (*G*), to take both the adjustable thumb screws (*I*) and the stud (*F*)*. As the spring is shortened by moving it farther toward the elbow, more work is thrown on the flexor muscles of the elbow. Great care must be exercised to guard against tiring the weakened muscles.

4. *To Support the Hand*

This was necessary for only a few months in the early phase of the disability. The hand support is made of a three-eighths-inch steel bar, three-quarters of an inch wide and of sufficient length to reach from the palm of the hand back into the trough (*K*), from which it can be removed when desired.

5. *To Allow Forward and Backward Motion of the Arm*

The steel rod (*M*) which supports the arm drops through a piece of steel tubing an inch long (*N*) into a steel well (*P*). This mechanism has proved most valuable, not only in giving free motion of the arm forward and backward, but in facilitating the putting on and taking off of the brace. To put it on, the body part of the brace is applied to the chest wall first, then rod *M* is dropped through tube *N* into well *P*. In Brace No. 2 (Fig. 3), rod *M* is short. After both the long and short rods had been tried, it was found that the long rod was preferable. The shorter one allows some wobbling and unnecessary wear of both the tube and the rod.

Operating Cuff and Technique

As the patient for whom this brace was made is a general surgeon, certain special features had to be incorporated to permit an adequate "scrub-up" technique. The forearm cuff is removable. When the surgeon is operating, the cuff is replaced by a shorter cuff which can be pushed up near the elbow; this permits scrubbing of over half of the forearm. To add further assurance against wound contamination, a sterile sleeve, extending from the wrist to the shoulder, is put on after scrubbing, before the hands are dried and the usual sterile operating gown is donned. This gives two thicknesses of sterile material over the elbow brace.

Arm Brace No. 2

Rest and moderate use of the arm and shoulder muscles resulted in partial return of function in this patient. In late May or early June of 1944, about twenty months after the operation, the patient noticed return of external rotation. Immediate studies were made to alter the brace in order to allow external rotation and also elevation of the arm, as the deltoid was also becoming stronger. Brace No. 2 (Fig. 3) was devised with a uni-

* In Brace No. 2, the stud (*F*) is substituted for thumb screw (*I*) to hold spring (*S*). With this brace, *I* is used only for fixation of the forearm cuff (*H*).

versal joint (C), provided for external and internal rotation of the arm. A compression spring (D) was added to supplement the function of the improving deltoid.

Universal Joint (C)

This joint is set about six centimeters in front of the center of the humerus, in order that the arm and forearm may counterbalance each other, making rotation easier. A steel ball (C) (Fig. 3, Inset *b*) is brazed to a milled fitting (R) and quenched. The steel ball rotates in a pressed socket, formed between a leverage arm (C_1) and a retaining plate (C_2) (Inset *c*). The leverage arm is screwed to the lower part of the steel arm bar (L_1), just above the stop joint (B).

The universal joint is supported by a three-sixteenths-inch steel supporting rod (Q), connecting the milled fitting (R) of the universal joint with the rod (M), which drops into the steel tube (N) on the side of the body brace. This supporting rod is hinged vertically to M, allowing vertical motion; Q is also hinged vertically at R.

Abduction of the Arm, Aided by Compression Spring (D)

The compression spring (D) substitutes for the weakened deltoid and coracobrachialis. The weight of the arm and the weight of the brace compress the spring down to a stop which will maintain the arm at 45 degrees of abduction while at rest. The spring must be strong enough just to balance the arm and brace weights at 45 degrees and also to compensate for the friction of the brace. The deltoid and coracobrachialis will, therefore, have to overcome only the inertia of the arm and the brace in order to further abduct. Several springs were wound before one was obtained, by trial and error, that would meet these requirements. The spring is made of 0.063 music wire, eight and three-quarters inches long, outside diameter five-sixteenths of an inch, with thirteen turns per inch. It rides on a three-sixteenths-inch steel rod, five inches long, welded into the milled fitting (R) at its lower end; the upper end plays freely in the lower hollow end of the steel rod (D_1). This rod is just long enough to stop the arm at 45 degrees of abduction. D_1 is a half-inch steel rod, two and one-half inches long, flattened and bored at the upper end to take a screw, fastening it to M, rotating vertically on the screw in M.

With brace No. 2, there has been increased function in the movements of the arm and forearm.

NOTE: Acknowledgment is hereby given to Alfred Blalock, M.D., and the late Walter Dandy, M.D., of the Johns Hopkins Hospital, and to Mr. and Mrs. Henry O. Kendall, Children's Hospital School, Baltimore, for many helpful suggestions.

It is possible that, in the future, hidden spring joints may be substituted at the elbow and shoulder, if they can be made sufficiently powerful. Under such circumstances, there would be less tearing of clothing. Leather coverings have been used over the springs to protect the clothing.

These braces have been submitted to the medical departments of the Army and Navy, and received special encouragement from Captain J. S. Barr and Lieutenant Commander Hunter Sheldon, formerly of the Naval Medical Center, and Captain Hugo B. Rizzoli, formerly of Walter Reed General Hospital.

Because of limitations of space, a full description of each of the parts is not included. Such a description, covering types of material and methods of manufacture, may be obtained by writing to the authors.

CONTROL OF FOREARM ROTATION BY A KIRSCHNER WIRE

BY STERLING BUNNELL, M.D., AND LOT D. HOWARD, JR., M.D.,
SAN FRANCISCO, CALIFORNIA

It is often necessary to immobilize the arm in some position intermediate between pronation and supination. The customary way to prevent the movement of pronation or supination is to apply a right-angled elbow splint or cast, reaching to the axilla. A simple method for temporary fixation is presented here, which in selected cases makes it unnecessary to splint above the elbow.

With the forearm placed in the desired degree of rotation, a firm Kirschner wire, snipped off obliquely with a wire cutter, is drilled through the ulna and well into the radius, just above the wrist. This effectively stops all pronation and supination. The wire is cut just outside the skin, and is withdrawn when its usefulness is over.

This procedure has been used routinely by the authors. It has proved very advantageous in preventing rotary displacement from an exact position, when a patient's hand is placed over his abdomen in the application of an abdominal pedicle skin flap.

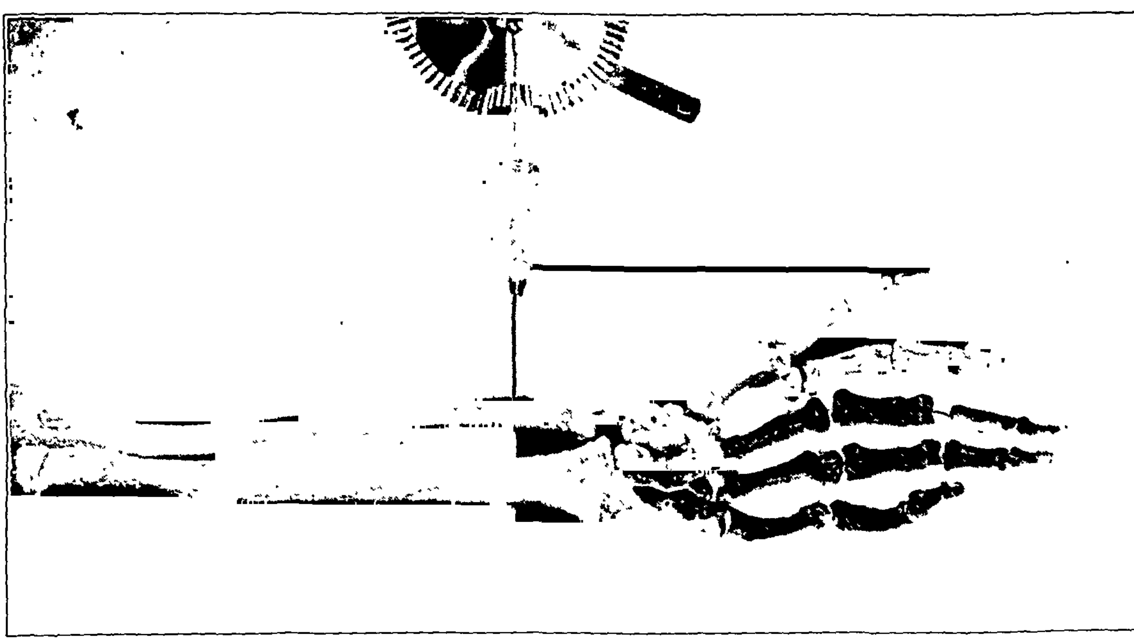

FIG. 1

Method of internal splinting with Kirschner wire, to maintain forearm rotation in any desired position. External splinting is not required.

The method is effective in arthrodesing a wrist.* For this purpose, the cast may terminate at the elbow, rather than being extended to the axilla. In Colles's fracture, pain is present in the distal radio-ulnar joint during the first three weeks, if the motions of pronation and supination are not checked. The pain may be avoided by such temporary pinning.

* In arthrodesis, the Kirschner wire should be imbedded in the cast.

THE TREATMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS BY KIRSCHNER-WIRE TRANSFIXION

BY ALVIN L. SWENSON, M.D., PHOENIX, ARIZONA

The treatment of supracondylar fractures of the humerus in children may be quite difficult if there is an unusual amount of swelling about the elbow. Extreme swelling, with blister formation, is generally found in patients who are first seen several days after the injury, or in whom previous attempts at reduction have been made. The ordinary closed reduction and immobilization with the elbow in acute flexion may be impossible, because of the danger of Volkmann's ischaemia. In patients with extensive swelling, elbow flexion much beyond a right angle may obliterate the radial pulse or shut off the venous return, whereas immobilization in the safer right-angle position will frequently allow the fracture fragments to slip.

Occasionally, supracondylar fractures of the humerus are difficult to hold in position, even though the elbow is not greatly swollen. A supracondylar fracture may be sufficiently oblique to make it difficult for a good reduction to be maintained, even though the limb is immobilized in marked flexion. In this type of fracture, the fragments are quite likely to slip if the arm is immobilized in a position approximating a right angle, because of marked swelling about the elbow. The rather rare "flexion" type of supracondylar fracture may be difficult to hold in position, because of the tendency of the distal fragment to become angulated or displaced anteriorly, as in the original deformity.

A relatively large number of cases involving the treatment of supracondylar fractures with extreme swelling were seen several years ago at the Crippled Children's Hospital in Oklahoma City. Of a total of sixty-one cases reviewed, seventeen had been seen two or more days after the injury, and in twenty-two, previous attempts at reduction had been made. Most of this group of thirty-nine patients had such extensive swelling about the elbow that it was impossible to carry out the usual method of closed reduction and splinting in acute flexion. Only thirty-two of the sixty-one cases showed moderate swelling; and these patients were seen early enough to permit closed reduction and immobilization of the extremity in acute flexion, thus maintaining the fracture fragments in good position during healing. Seven patients required two closed reductions in the Hospital. These second reductions were necessary because the extensive swelling about the elbow at the time of the first reduction, and inability to obtain or maintain sufficient elbow flexion, caused slipping of the fragments. A further review of the method of treatment showed that sixteen children had such extensive swelling, with blister formation about the elbow, that the treatment of choice consisted of suspended traction with a wire through the olecranon. In six patients, the fractures were treated by open reduction, because of inability to obtain satisfactory reduction by conservative treatment (Figs. 1-A, 1-B, and 1-C).

The maintenance of reduction in many types of fractures has been accomplished frequently by the use of transfixing pins or wires. Miller [1] has described a method of blind nailing of T fractures of the lower end of the humerus, which involve the joint. In the treatment of supracondylar fractures in children, with marked swelling, the writer has placed transfixing wires across the fracture, thereby pinning the distal fragment to the humeral shaft. This principle is an extension of the method of Kirschner-wire transfixion of certain types of elbow fractures, described by Miller, to the treatment of supracondylar fractures in children, but differs from his method in the direction the wires are to be inserted. After the fracture has been reduced and has been transfixed by wires, the elbow need not be placed in acute flexion, but may be splinted at an angle of 90 or 100 degrees: this position does not endanger the circulation below the swollen elbow. There is very little pain following this method of wire fixation, and the patient is allowed to become ambulatory and to go home in a few days.

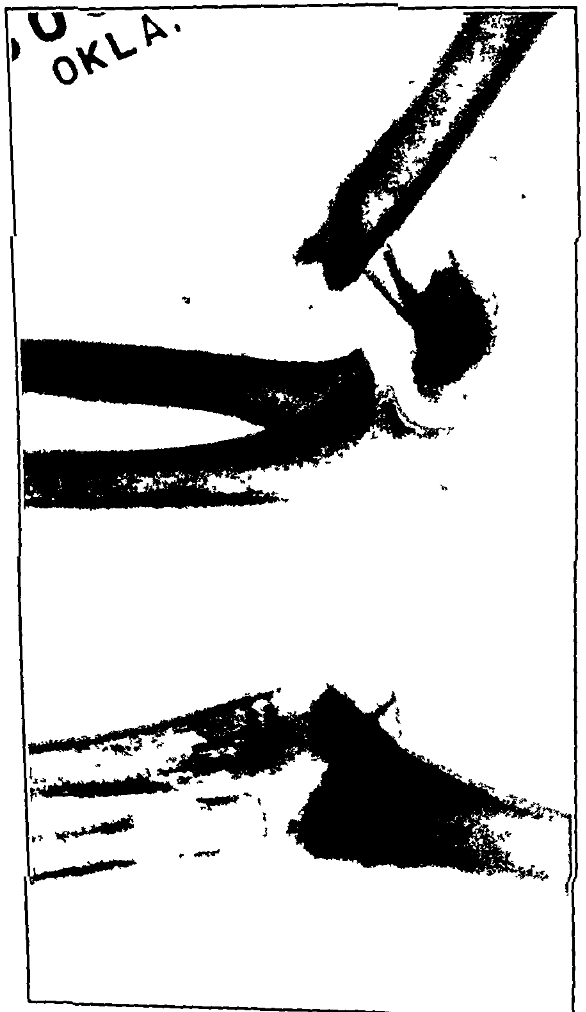

Fig. 1-A

Fig. 1-B

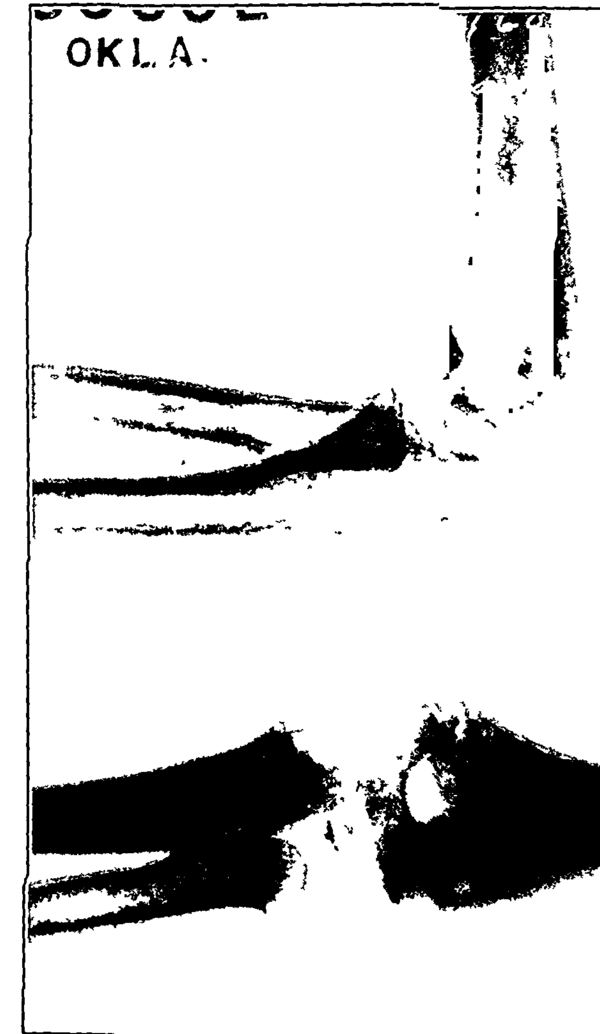

Fig. 1-C

Fig. 1-A: F. V. Aged seven. March 28. Roentgenograms show supracondylar fracture of the left humerus on admission. Considerable swelling with marked posterior displacement of distal fragment.

Fig. 1-B: April 10. Roentgenograms taken thirteen days later show reduction being maintained by transfixing wires. Arm is immobilized in posterior splint with elbow flexed to 90 degrees.

Fig. 1-C: May 1. Roentgenograms show position of fracture following removal of wires.

TECHNIQUE OF OPERATION

After the fracture has been completely reduced, the insertion of the transfixing wires not difficult. The reduction is checked by roentgenograms, and if found satisfactory, assistant holds the arm on an arm board, with the elbow acutely flexed to maintain the duction, even though the radial pulse is temporarily obliterated. The elbow is allowed to end beyond the end of the arm board and is prepared for operation. Using sterile technique, the surgeon then selects two Kirschner wires of slightly different diameter; one short schner wire is drilled through each condyle, across the fracture line, and into the umeral shaft. In an extremely swollen elbow, it is difficult to palpate the condyles, but ter some of the oedema has been pressed away, the bony landmarks can generally be identified. The condyles can be palpated with the points of the wires, however, and some resistance may be noticed while the wires are being drilled through the bone. Because of the forward curve of the distal end of the humerus, and the increased width at the condyles, the wires must be directed slightly posteriorly and inward, at an angle of 30 or 40 degrees with the humerus, so that the shaft will not be missed (Figs. 2-B and 2-C).

In the placing of the wires, or in the palpating of the condyles with the points of the wires, the elbow joint may be punctured, especially if the wires are not inserted in the lateral portion of the condyles, if they slide off anteriorly or posteriorly during the drilling, or if they are directed inward at an angle greater than 30 or 40 degrees. Such a puncture of the

Fig. 2-A

Fig. 2-B

Fig. 2-C

Fig. 2-A: D. W. Aged six. Roentgenogram shows supracondylar fracture of the right humerus, treated by closed reduction on previous day. Distal fragment has slipped posteriorly. Marked swelling about elbow prevented immobilization in more flexion.

Figs. 2-B and 2-C: Roentgenograms show position of fracture after second closed reduction and insertion of transfixing wires. Note that one wire is slightly larger than the other. Transfixing pins are shown within the humeral shaft, holding the distal fragment in good position.

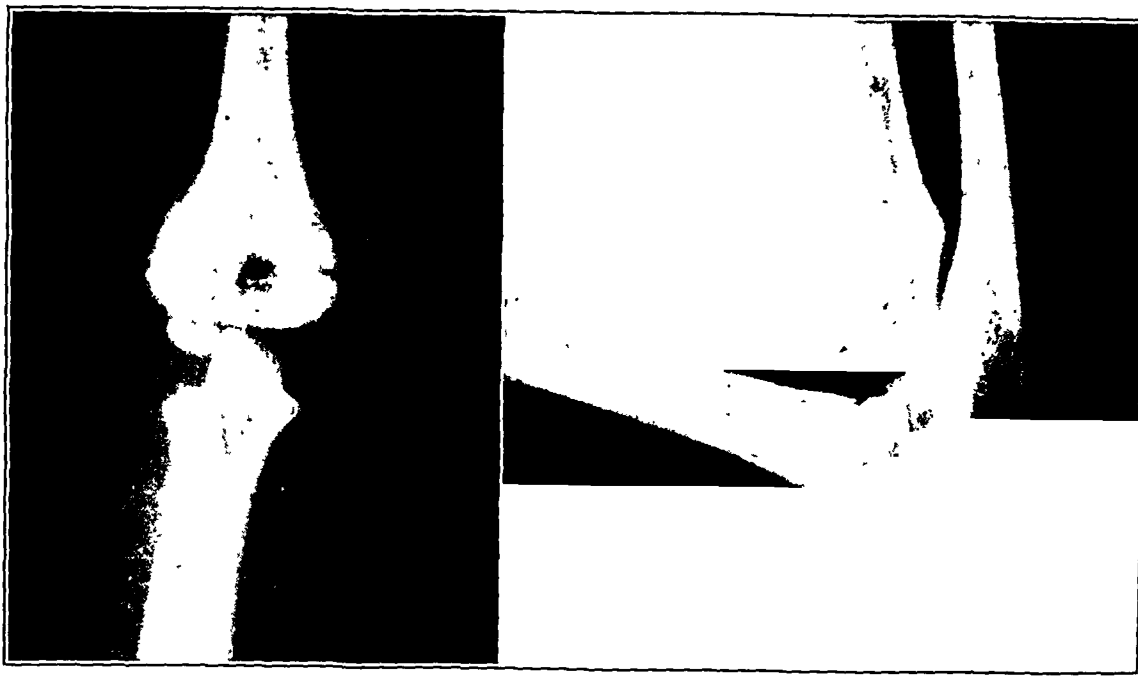

Fig. 2-D
Roentgenograms show position of fracture nineteen days after reduction and after removal of wires.

Fig. 2-E
Photographs taken about three months after injury.

joint generally produces no complications, unless infection is introduced by the wires. Properly placed, the wires penetrate the medial and lateral condyles, where the common flexor and the common extensor tendons attach themselves. The wires do not enter the elbow joint, since the capsule is attached just medial to the trochlea on the medial side, and just lateral to the capitellum on the lateral side. The wires should be inserted in the bone just beneath the condylar ridges, and should strike the opposite side of the humerus about one and one-half inches above the fracture line.

It must be remembered that the humerus is very thin in the supracondylar area, and that the wires may miss the humerus, if the fracture has not been completely reduced. Care must be taken not to injure the ulnar nerve, near the medial condyle. Roentgenograms are taken to determine whether or not the wires are properly placed in the bone. When the lateral roentgenogram shows that one of the wires is outside the shaft, it is easier to determine whether the wire to be changed is the lateral or medial one, if wires of slightly different diameters are used. When the wires are in a satisfactory position, they are cut off at the skin surface, and the skin is pulled over them. A sterile dressing is used to cover the elbow, and a posterior splint is applied, with the elbow in approximately 90 degrees of flexion. The wires are removed in about three weeks, under local anaesthesia; the splint may be continued for a few days longer (Figs. 2-A, 2-B, 2-C, 2-D, and 2-E).

This method of blind pinning has been used in the treatment of ten cases of supracondylar fractures in children where extreme swelling was present about the elbow. There have been no infections around any of the wires, and in none of the patients has circulatory difficulty or Volkmann's ischaemia developed. In none of these cases has it been necessary to use olecranon-wire traction. The wires have held the original reduction until

union occurred, without slipping, in all but one case. In this instance, the fracture slipped because one wire, which was first thought to be within the bone, proved to be outside the shaft, necessitating a second reduction and the insertion of another wire. No difficulty has been experienced in removing the wires under local anaesthesia, since the wires become prominent under the skin after the swelling has subsided. No cases of injury to the ulnar nerve were encountered, and after removal of the splints, the patients made satisfactory progress in regaining elbow motion.

CONCLUSIONS

The use of transfixing wires in the treatment of difficult cases of supracondylar fractures of the humerus in children is especially useful for patients who have such extensive swelling about the elbow, when first seen, that immobilization in acute flexion, following a closed reduction, cannot be carried out. Olecranon-wire traction is not necessary, since the transfixing wires maintain the original reduction until union occurs. The danger of Volkmann's ischaemia is lessened, since splinting in acute flexion is not necessary. Ten patients, first seen from two to six days following the injury, have been successfully treated by this method of blind pinning.

1. Miller, O. L.: Blind Nailing of the T Fracture of the Lower End of the Humerus Which Involves the Joint. J. Bone and Joint Surg., 21: 933–938, Oct. 1939.

AN OPERATION FOR OLD DISLOCATION OF THE SHOULDER

BY JULIUS S. NEVIASER, M.D., WASHINGTON, D. C.

The results of treatment of old dislocations of the shoulder, whether the treatment is of the conservative or the operative type, are frequently unsatisfactory. In cases characterized by intractable pain from pressure upon the brachial plexus, operation is usually indicated. Two obstacles encountered at open reduction are, first, difficulty in replacing the humeral head because of fibrosis and shortening of the muscles, contracture of the capsule, and the presence of scar tissue in the glenoid fossa; and, second, difficulty in maintaining the reduction because of damage to the anterior portion of the capsule. In chronic dislocations, use of the tendon of the long head of the biceps to prevent redislocation has frequently been unsuccessful.

These difficulties may be lessened materially by use of the technique to be described. The operation was performed first upon a patient whose shoulder had become redislocated after an open reduction with implantation of the tendon of the long head of the biceps into the humeral head. It has now been used in six cases of old anterior dislocation. In all of these patients, attempts at closed reduction had been made; all had had a serious amount of persistent pain.

OPERATIVE TECHNIQUE

The usual anterior incision is made in the deltopectoral groove. The muscles are separated and retracted to expose the capsule, which stretches across the glenoid fossa. The capsule is opened by a longitudinal incision, about 4.5 centimeters in length, just lateral to the insertion of the subscapularis tendon. It is unnecessary to cut the subscapularis muscle; one of the hazards to the nerve supply of the deltoid is thus obviated. The attachments of the capsule to the neck of the humerus are stripped away by the use of a sharp curved periosteal elevator or a goose-neck chisel, aided by the fingers. The stripping should be carried beyond the greater tuberosity, and should include a portion of the neck below the lesser tuberosity. Subperiosteal separation of the muscles from the tuberosities does not interfere with their attachments to the musculotendinous cuff. In some instances, the parts of the capsule that require stripping can be identified by palpation, with one or two fingers inserted through the opening in the capsule. After thorough subperiosteal stripping, the head is sufficiently mobile to allow replacement without undue tension. The glenoid fossa is palpated and cleared of scar tissue. The surgeon then effects

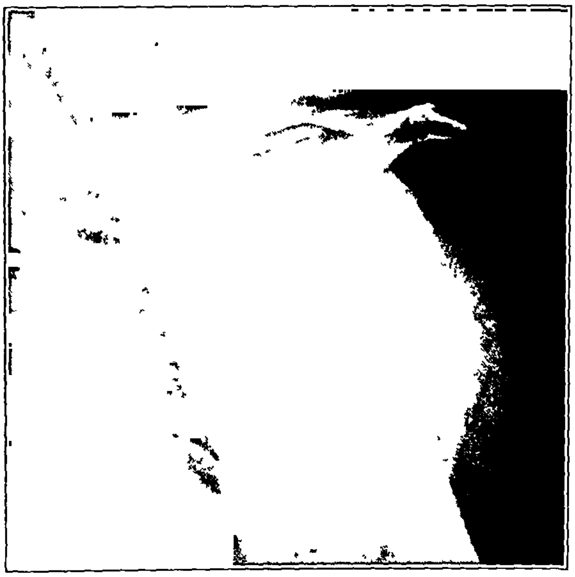

FIG. 1-A

FIG. 1-B

Fig. 1-A: Case 4. Dislocation of the left shoulder, one month after injury.
Fig. 1-B: Vitallium screw holding the head in satisfactory position.

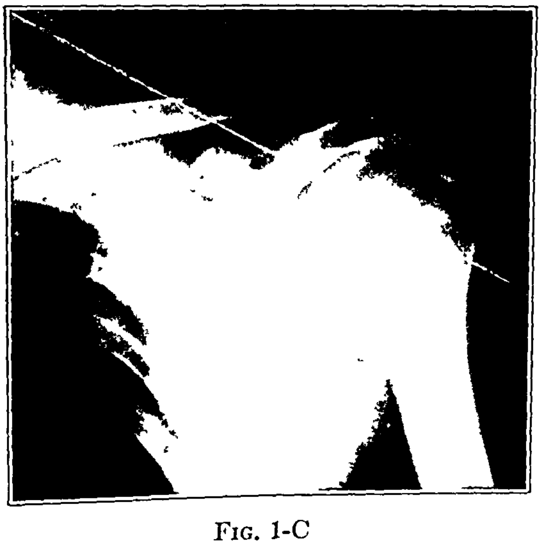

FIG. 1-C

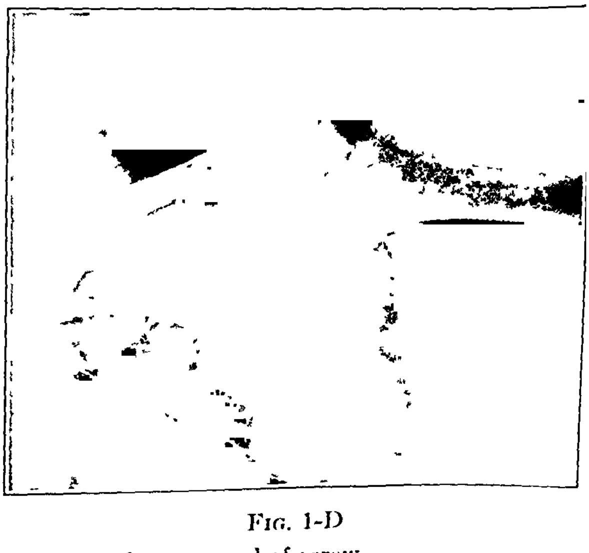

FIG. 1-D

Fig. 1-C: Reduction maintained six weeks after removal of screw.
Fig. 1-D: Range of abduction, eight weeks after operation.

reduction by pushing the humeral head laterally and posteriorly with one hand, while his other hand exerts a leverage action on the patient's elbow.

An important part of the operation is the procedure for holding the head of the humerus in proper alignment. A small incision is made through the skin and other soft tissues directly lateral to the head of the humerus, and a long wood screw of Vitallium is inserted through the head into the glenoid fossa. If the capsule can be closed or its edges sutured close to the head without tension, this is done; if not, no attempt is made to close or repair the anterior portion of the capsule. It is believed that the remnants of the capsule contract about the head during the healing process, and that by the time the screw is removed, the head will be held firmly in proper position. For about ten days the patient's arm is strapped to his side in the position determined by the screw: then, after removal of the sutures, it is placed in a sling. Flexion and extension of the shoulder are encouraged while the arm is supported by the sling. Three or four weeks after operation the lateral operative scar is excised and the screw is removed. About a week later, when the wound of the second operation has healed, the sling is discarded, physical therapy is begun, and use of the arm is encouraged.

After this operation the patients have been relieved of their pain and the affected shoulders have regained useful function. The author believes that, if the arm can be actively abducted at the scapulohumeral joint to an angle of 60 degrees, the result may be considered satisfactory. One patient of the present series could abduct the shoulder operated upon to 90 degrees. No harmful changes due to insertion of the screw through the humeral head and the glenoid fossa have been shown in roentgenograms.

CASE REPORTS

CASE 1. W. A., a male, aged forty-four years, was admitted to the hospital on December 12, 1942, with pain in his left shoulder, which had been injured. Roentgenograms showed a subcoracoid dislocation six weeks before. After manipulation under anaesthesia had proved unsuccessful, an open reduction was performed on December 16; and an attempt was made to hold the head of the humerus in position by means of the long head of the biceps, according to the method of Nicola. Postoperative roentgenograms showed the head to have been redislocated. On February 2, 1943, a second open reduction was carried out and the head of the humerus was held in position by means of a long Vitallium screw. Roentgenograms showed that the reduction was well maintained. The screw was removed four weeks after operation. An infection retarded this patient's recovery and delayed the beginning of his shoulder exercises. He was followed until September 1943; at that time he had no pain and had regained a range of active scapulohumeral abduction of 60 degrees.

CASE 2. M. J., a woman, aged sixty-eight years, was admitted to the hospital on April 9, 1945. Seven weeks before, she had fallen down steps and incurred a dislocation of the right shoulder. Following an unsuccessful attempt at closed reduction, the shoulder was reduced at open operation on April 11, and the reduction was maintained by means of a Vitallium screw. On May 16, the screw was removed under pentothal anaesthesia. After discharge from the hospital, the patient had no pain; her arm could be abducted at the scapulohumeral joint actively to 45 degrees and passively to 90 degrees. The range of external rotation was 45 degrees: the patient could place her hand behind her back just above the belt level. Five months later, abduction could be carried out actively to 60 degrees and other movements were of about the same range as at the previous examination. Roentgenographically, the shoulder was normal.

CASE 3. J. S., a woman, aged sixty-two years, was admitted to the hospital on March 20, 1946. Two and one-half months before, she had fallen and injured her right shoulder. Roentgenograms disclosed a subcoracoid dislocation. An attempt at closed reduction, nine weeks before admission, had been unsuccessful. On March 23, open reduction and fixation with a Vitallium screw were carried out. While a bleeding vessel was being clamped, the posterior cord of the brachial plexus was pinched: this resulted in weakness of the deltoid muscle and the extensors of the wrist. On April 11, nineteen days after operation, the screw was removed. The patient received intensive physical therapy. She was last observed on December 5, 1946, at which time there was still weakness of the deltoid and wrist extensors, but no pain. At the scapulohumeral joint the arm could be abducted to 80 degrees and externally rotated 75 degrees. Upon internal rotation, the patient could touch her right buttock with her right hand. Flexion and extension of the shoulder were of satisfactory range, and there was no pain.

CASE 4. J. M., a man, aged fifty-five years, was admitted to the hospital on January 28, 1946, because of pain in the left shoulder and numbness of the left hand. A month before admission he fell and sustained a dislocation of the left shoulder (Fig. 1-A). Two attempts at closed reduction proved unsuccessful. At operation, on February 20, reduction was easily accomplished after the capsule had been incised and stripped from the humerus. A Vitallium screw was inserted. Postoperative roentgenograms (Fig. 1-B) showed the position to be satisfactory. The screw was removed on March 14, three weeks after operation. Pendulum exercises were carried out for one week with the arm in a sling, after which the physical therapy was increased and active use of the shoulder was encouraged. The humeral head remained in proper position (Fig. 1-C). Maximum abduction eight weeks after operation is shown in Figure 1-D. The patient was last observed two and one-half months after operation, at which time the arm could be abducted actively at the scapulohumeral joint to 75 degrees, and passively to 85 degrees. It could be externally rotated 65 degrees. The patient could internally rotate his shoulder sufficiently to touch the middle of his back at the belt level. He no longer had pain in the left shoulder, and the numbness of his hand had disappeared.

CASE 5. V. H., a man, aged forty-nine years, was admitted to the hospital on February 9, 1946, because of pain in the left shoulder. About five weeks before admission, he had fallen down steps and injured his left shoulder. On admission, he complained of persistent pain in the shoulder and of numbness of the left hand of five days' duration. The head of the humerus could be palpated anteriorly. Active abduction was limited at 30 degrees, and no active rotation could be carried out. Roentgenograms showed a fracture-dislocation of the left shoulder. At operation, on February 15, the head of the humerus was reduced and held in position by means of a long Vitallium screw. The screw was removed on March 7, twenty days after operation, and the patient was allowed to use the arm in a sling. A week later roentgenograms showed that the head was in satisfactory position; the sling was discarded and physical therapy was started. Three months after operation, the patient had no pain and the numbness of his left hand had disappeared. He could actively abduct the arm at the scapulohumeral joint to 60 degrees, could externally rotate it 30 degrees, and on internal rotation could touch the middle of his back at the belt level.

CASE 6. F. D., a woman, aged thirty-nine years, fell on her outstretched hand on March 13, 1947, and sustained a fracture-dislocation of her left shoulder. An attempt at closed reduction on the day of injury had been unsuccessful. Pain and stiffness of the left shoulder, and pain, numbness, and swelling of the left hand were present on May 2, at the time of admission. Active abduction of the shoulder was limited at 30 degrees, external rotation at 10 degrees, and internal rotation at 20 degrees. A second manipulation was unsuccessful. Accordingly, on May 6, open reduction was carried out and a long screw was used to hold the head of the humerus in position. The screw was removed on June 2. Physical therapy was started shortly afterward. When the patient was discharged from active treatment on November 24, six months after operation, she had no pain or swelling. Her arm could be abducted at the scapulohumeral joint actively to 90 degrees and passively to 120 degrees. External rotation was limited at 80 degrees; the range of internal rotation allowed the patient to touch the middle of her back three inches above the belt level.

SUMMARY

This operation for old dislocation of the shoulder offers the following advantages:

1. The reduction is facilitated by opening the joint capsule and stripping it from the upper end of the humerus.
2. The danger of injuring the axillary nerve is minimized by avoiding division of the subscapularis.
3. The relationship of the tendons to the musculotendinous cuff is undisturbed.
4. Immediate redislocation is prevented by internal fixation with a transfixing screw.
5. Surgical repair of the joint capsule is obviated, and the capsule can be allowed to heal and contract.
6. Stiffness of the shoulder joint is minimized by mobilization after early removal of the transfixing screw.

CONGENITAL BILATERAL COMPLETE ABSENCE OF THE RADIUS IN IDENTICAL TWINS

BY RAPHAEL R. GOLDENBERG, M.D., PATERSON, NEW JERSEY

From the Orthopaedic Service, St. Joseph Hospital, Paterson

Since a review of the available literature does not contain a report of congenital bilateral complete absence of the radius in twins, the following cases were considered worth recording.

W. E. and R. E., twin boys, have been observed since three months after their birth in December 1938. They weighed four pounds, two ounces, and three pounds, nine ounces, respectively, at birth. Physical examination of the other known members of the family revealed no evidence of congenital deformity. Each child presented bilateral club-hand with complete bilateral absence of the radius and of the thumb (Fig. 1). W. E. had four fingers on the right hand, and two fingers (index and middle) on the left hand. R. E. had four fingers on each hand. Complete elbow motion was present in each child, except that in the left elbow of W. E., flexion was possible to only 90 degrees. The only other evidence of congenital abnormality was a spina bifida occulta in each child, as demonstrated by roentgenographic examination.

At four months of age, treatment in the form of wedging plasters was instituted. The deformities were corrected and braces were applied to maintain the corrected position. In spite of constant external fixation, the deformities recurred.

Roentgenograms of W. E., taken on August 13, 1946, showed bilateral complete absence of the radius. The ulna was thickened, with slight palmar angulation in its distal third. The right forearm (Fig. 2-A) showed four carpal and four metacarpal bones with four phalanges. The left forearm (Fig. 2-B) showed three poorly differentiated carpal bones, and three metacarpal bones with two phalanges. The first metacarpal bones and the thumb phalanges were absent bilaterally Roentgenograms of R. E., taken on August 13, 1946, showed bilateral complete absence of the radius. The ulna was thickened and angulated, as in the case of W. E. The right forearm (Fig. 3-A) and the left forearm (Fig. 3-B) showed four distinct carpal and four metacarpal bones with four phalanges. The first metacarpal bones and the thumb phalanges were absent bilaterally.

On January 9, 1947, when W. E. was nine years of age, a dorsoventral lineal osteotomy, as described by Bardenheuer [1], was performed on the right ulna. The distal two and one-half inches of the ulna was osteotomized. The freed radial half of the distal third of the ulna, together with half of the distal ulnar epiphysis, was transplanted and fixed between the second and third metacarpal bones. The proximal portion of the graft was fitted into a previously prepared notch on the radial aspect of the ulna. The limb was immobilized in a circular plaster-of-Paris dressing. Six weeks later, a similar operation was performed on the left forearm. The same operative procedure was carried out on both forearms of R. E. At the

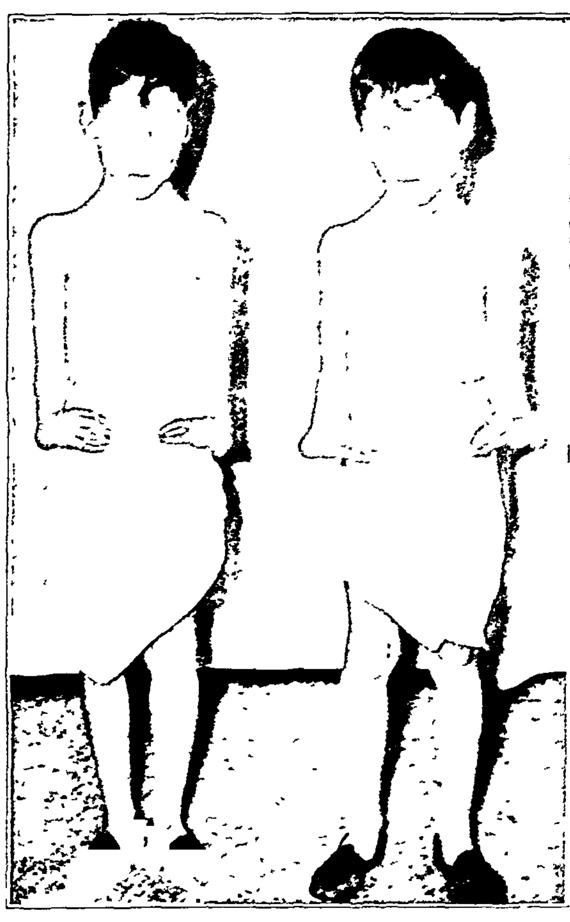

FIG. 1

Preoperative photograph showing congenital club-hand deformities in twins.

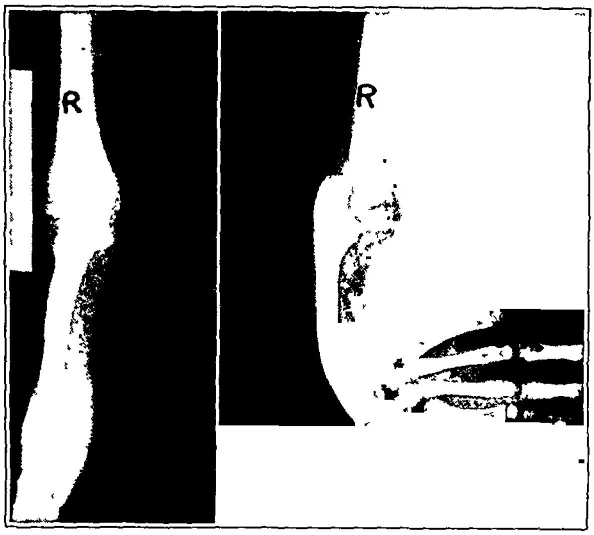

Fig. 2-A

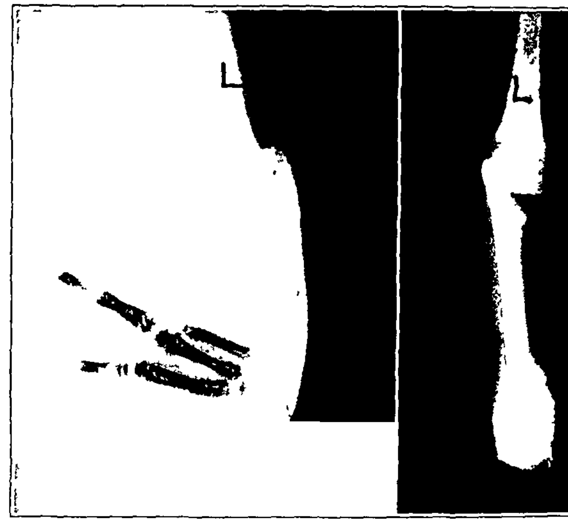

Fig. 2-B

Roentgenograms of the right and left forearms of W. E., taken August 13, 1946.

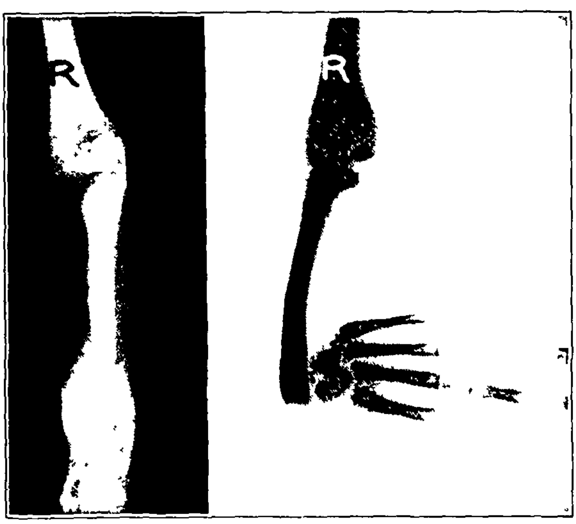

Fig. 3-A

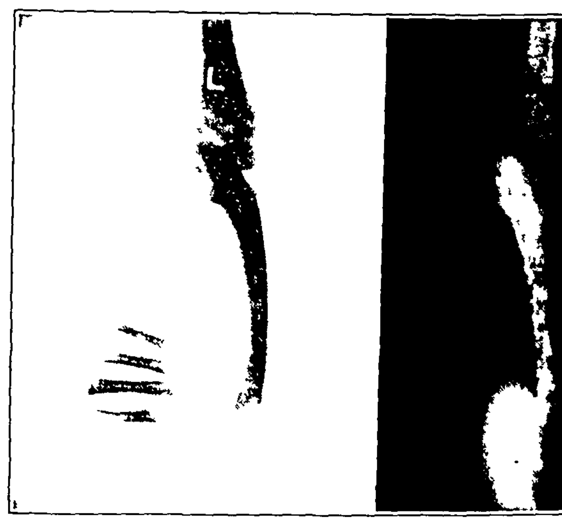

Fig. 3-B

Roentgenograms of the right and left forearms of R. E., taken August 13, 1946.

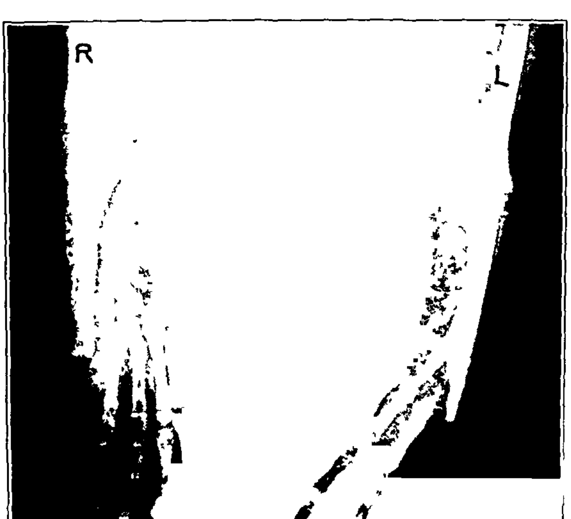

Fig. 2-C

Anteroposterior roentgenograms of both forearms of W. E., taken September 9, 1947, showing absorption of the graft on the right side.

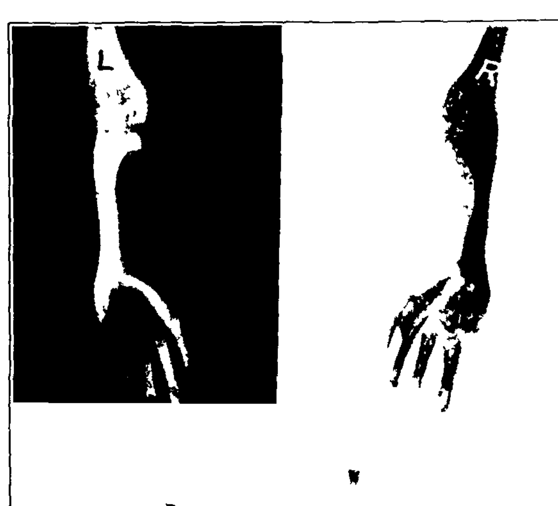

Fig. 3-C

Anteroposterior roentgenograms of both forearms of R. E., taken September 9, 1947.

time of fixation of the proximal end of the graft into the previously prepared notch, the ulna was fractured. Postoperative roentgenograms of the right and left forearms showed the position of the bone grafts.

Plaster immobilization was discontinued on September 9, 1947. Clinical examination at that time revealed improved alignment of the hands (Fig. 4).

The operative result in the left hand of each child was satisfactory, since fusion of the left wrists was complete. The operative result in the right wrist of each patient was unsatisfactory. Anteroposterior roentgenograms, taken on September 9, 1947, showed that the grafts were well healed on the left forearms. The proximal end of the graft on the right forearm of each child had been absorbed (Figs. 2-C and 3-C).

The parents were informed that, since the deformities would recur in the right hands, reoperation with a tibial graft was indicated. Permission for the operations was denied. When deformities of the right hand do recur, operative permission will be granted.

FIG. 4

Showing the improved position of the hands.

1. BARDENHEUER: Vorstellung von 4 Patienten, an welchen die totale Hüftgelenksresection mit totaler Pfannenresection ausgeführt worden war. Verhandl. d. Deutschen Gesellsch. f. Chir. (Dreiundzwandzigster Congress), 23: 85–87, 1894.

BILATERAL TRAUMATIC SLIPPING OF THE PROXIMAL EPIPHYSIS OF THE HUMERUS

REPORT OF A CASE

BY R. D. BUTTERWORTH, M.D., AND EARNEST B. CARPENTER, M.D., RICHMOND, VIRGINIA

From the Medical College of Virginia Hospitals, Richmond

Traumatic separation, fracture, or dislocation of the proximal epiphysis of the humerus has frequently been reported and is not uncommon in orthopaedic practice. However, a careful review of the literature from 1900 to the present time reveals no reported case of bilateral separation of the proximal epiphysis of the humerus of traumatic origin. The following case is reported because of the unusual trauma involved.

R. R., a sixteen-year-old white male student, was admitted to the Medical College of Virginia Hospital on April 2, 1947, following an automobile accident: he had been thrown from the rear of a truck when the vehicle struck a tree, while travelling at high speed. The boy was unconscious for a few minutes after the accident. He did not remember how he struck the ground, but in view of the resultant trauma, he probably landed on his outstretched arms.

On admission to the Hospital, the patient complained of severe pain in both shoulders with inability to move either upper extremity. Examination revealed a well-developed, well-nourished, healthy young male. The blood pressure was 118 systolic and 74 diastolic, pulse 88, and respirations 22 per minute. Multiple bruises and excoriations were present over the entire body and head. There was marked deformity of both shoulders, with adduction of the proximal portions of the humeral shafts. The appearance of the shoulders clinically resembled bilateral subglenoid dislocation. The remainder of the physical examination was negative. Roentgenograms (Figs. 1-A and 1-B), taken at the time of admission, showed complete bilateral separation of the proximal humeral epiphyses. Roentgenograms of the skull were negative.

FIG. 1-A

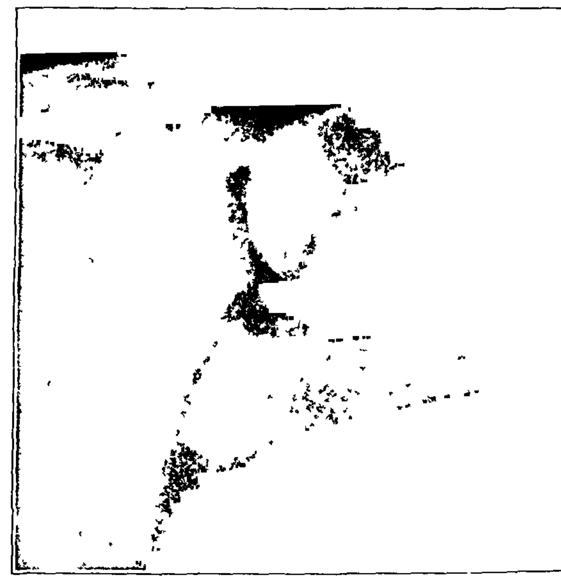

FIG. 1-B

Roentgenograms of right (Fig. 1-A) and left (Fig. 1-B) shoulders at the time of admission to the Hospital.

FIG. 2-A

FIG. 2-B

Roentgenograms of both shoulders at the end of sixteen weeks.

With gas, oxygen, and ether anaesthesia, the epiphyseal dislocations were reduced under fluoroscopic vision, without difficulty. Following reduction, a Velpeau dressing was applied to each arm. The patient's recovery was uneventful, and roentgenograms taken at the end of eight and of sixteen weeks (Figs. 2-A and 2-B) showed abundant callus formation, with excellent position of the head in relation to the shaft on each side. Marked deltoid atrophy was seen bilaterally at the end of eight weeks, but the range of motion of both shoulders was excellent. However, at the end of sixteen weeks residual atrophy of the deltoid on the left was noticed; the right deltoid had regained its normal tone and function. Neurological examination revealed partial paralysis of the axillary nerve on the left. Examination at the end of twenty weeks showed improvement of the axillary-nerve paralysis on the left. At that time there was a good range of motion of both shoulders. The deltoid atrophy was still marked.

BILATERAL FRACTURE OF THE PARS INTERARTICULARIS OF A LUMBAR NEURAL ARCH

BY MAURICE B. ROCHE, M.D., ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University School of Medicine, St. Louis

The genesis of a defect or solution of continuity in the interarticular portion of the neural arch of a vertebra, known as "spondyloschisis", has been considered by some writers as congenital, by others as due to trauma [1, 2, 3, 5, 7, 8]. Hitchcock demonstrated, by presenting three cases of spondylolisthesis with roentgenographic evidence of progressive slipping of the fifth lumbar vertebra on the sacrum, that the region of congenital defects at the pars interarticularis is more susceptible to trauma than normal, intact portions of the spinal column. It is true, however, that an intact portion of the spinal column, free from congenital defect, is also susceptible to acute traumatic spondyloschisis. Such a case in a well-developed male adult is presented here, with roentgenographic evidence of the acute fractures and of osseous healing.

V.C.B., aged twenty-two years, was admitted to the Hospital on February 1, 1947. On this date, the jeep in which he was riding accidentally overturned and he sustained multiple injuries. Examination at the time of entrance to the Hospital revealed a dislocation of the left shoulder, a fracture of the left scapula, a fracture of the transverse processes of the fourth and fifth lumbar vertebrae, and fractures of both sides of the pelvis, including both ischial and pubic rami. The dislocation of the left shoulder was reduced and, because of the multiple injuries, the patient was placed on a Stryker frame. Additional portable roentgenograms were then taken of the lumbar spine; bilateral fractures, involving the isthmuses on both sides of the neural arch of the third lumbar vertebra, were demonstrated in the anteroposterior, lateral, right, and left postero-oblique views (Figs. 1-A to 1-E). The patient remained on the Stryker frame, for immobilization of the back and pelvic fractures, until May 30, 1947, at which time roentgenographic examination disclosed new-bone formation

FIG. 1-A

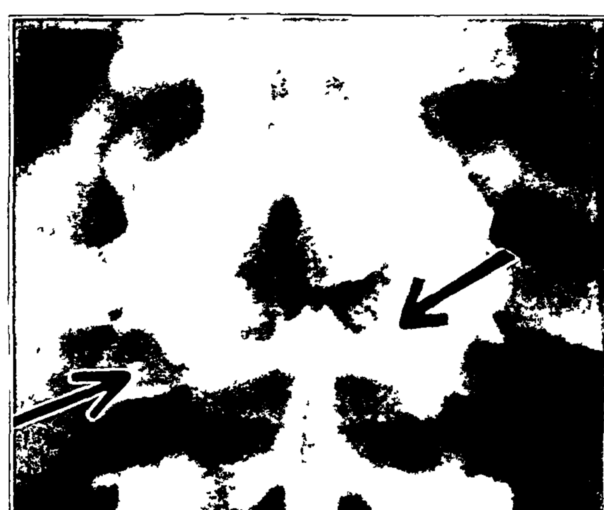

FIG. 1-B

Fig. 1-A: V.C.B. Anteroposterior view of lumbar spine, showing bilateral laminar fracture of the third lumbar vertebra.

Fig. 1-B: Enlarged anteroposterior view, to emphasize bilateral laminar fracture of the third lumbar vertebra.

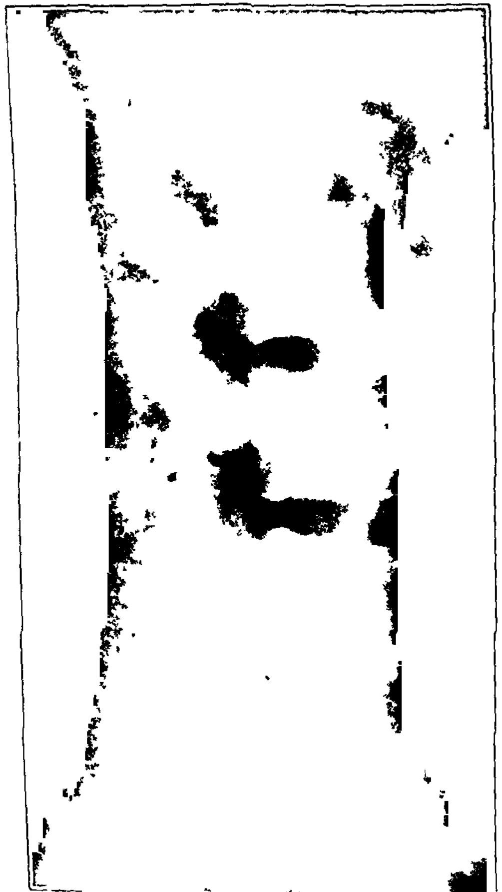

FIG. 1-C

FIG. 1-D

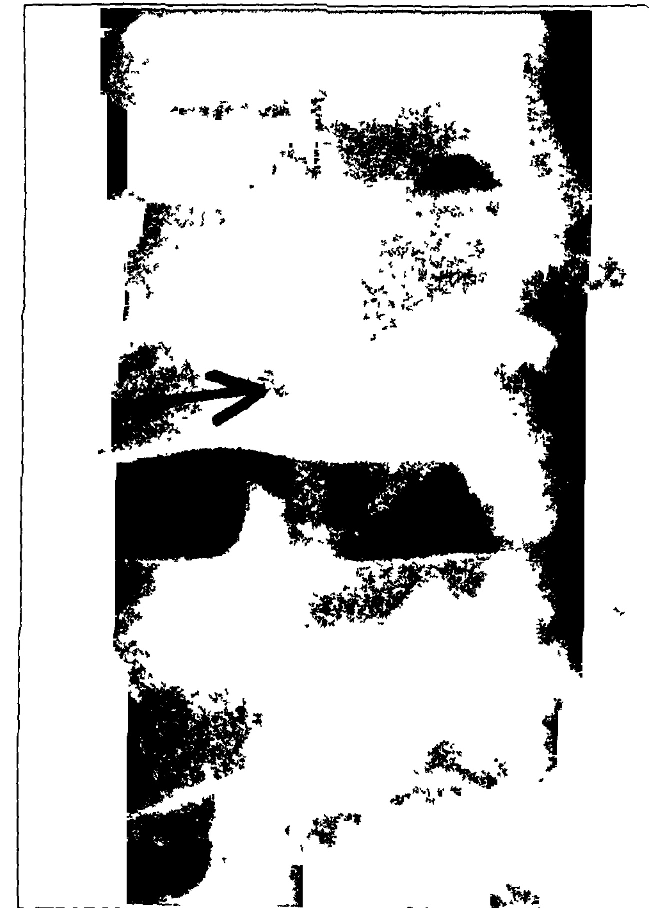

FIG. 1-E

Fig. 1-C: Lateral view of lumbar spine, showing laminar fractures of the third lumbar vertebra. Note that there is no attendant compression fracture of the body of the involved vertebra, nor is there any dislocation on the one below (spondylolisthesis).
Fig. 1-D: Enlarged right postero-oblique view of the fractured right pars interarticularis of the third lumbar vertebra (acute traumatic spondyloschisis).
Fig. 1-E: Enlarged left postero-oblique view of the fractured left pars interarticularis of the third lumbar vertebra.

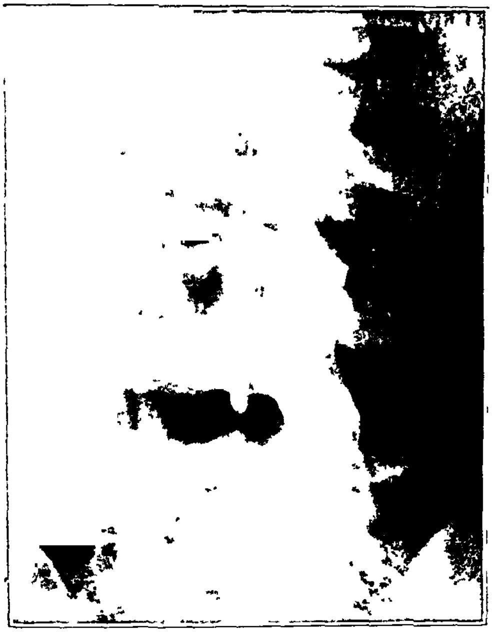

Fig. 2-A

Fig. 2-B

Fig. 2-A: Anteroposterior view, showing healed sites of laminar fractures of the body of the third lumbar vertebra.

Fig. 2-B: Lateral view of the lumbar spine, showing osseous healing of fracture sites through the lamina of the third body Note absence of spondylolisthesis.

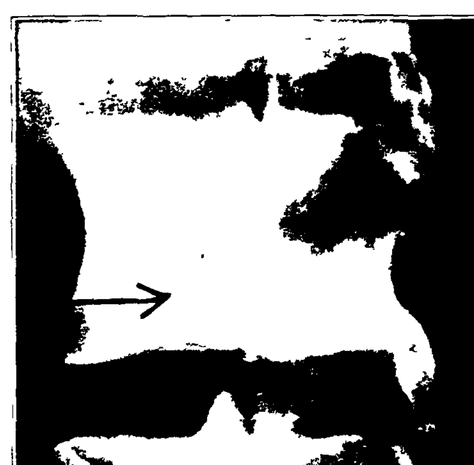

Fig. 2-C

Fig. 2-D

Fig 2-C: Enlarged right postero-oblique view, showing the healed site of fracture through the right pars interarticularis of the third lumbar vertebra.

Fig. 2-D: Enlarged left postero-oblique view of the third lumbar vertebra, showing healed fracture site in the left pars interarticularis

with healing of the fractures of the isthmuses of the third lumbar vertebra (Figs. 2-A to 2-D) The pelvic and scapular fractures were also firmly united A normal range of motion was present in the left shoulder The patient was fitted with a Taylor spine brace, and was allowed to sit up and gradually to resume normal activity.

Very little mention is made in the literature or in textbooks on fractures of this seemingly unique lesion,—acute traumatic spondyloschisis unaccompanied by spondylolisthesis. Ghormley and Hoffmann reviewed 823 cases of vertebral fractures of all types,

encountered in the Mayo Clinic from 1935 to 1939, inclusive. Fifty-one were fracture-dislocations. In 90 of the 772 remaining cases, lesions of the neural arch and processes were present. Of these cases, thirty-three (forty lesions) occurred in the cervical region, four (five lesions) in the thoracic region, and fifty-three (one hundred and six lesions) in the lumbar region. A breakdown of these lesions revealed fractures of the odontoid process (seven cervical); of the laminae (nine cervical and five lumbar); of the articular facets (one cervical and thirteen lumbar); of the pedicles (three cervical and six lumbar); of the spinous processes (eleven cervical, four thoracic, and two lumbar); of the transverse processes (eight cervical, one thoracic, and eighty lumbar); and of the lateral masses (one cervical). No instance of a fracture through the isthmus of the lamina was noted in this series of 823 cases.

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A LOCK SCREW FOR ATTACHING THE INTERTROCHANTERIC PLATE TO THE SMITH-PETERSEN NAIL

BY JAMES R. HERZ, M.D., KANSAS CITY, MISSOURI, AND
LOUIS W. BRECK, M.D., AND W. COMPERE BASOM, M.D., EL PASO, TEXAS

The authors have designed a lock screw for securing an intertrochanteric plate to a Smith-Petersen nail. The cannulated Smith-Petersen nail has been modified to receive a concentric screw, threaded for the left hand; this is inserted through a hole in the ordinary right-hand No. 1/4-20 screw (1/4 inch in diameter, 20 threads to the inch), attaching the plate to the nail.

The present modification, combined with the lock screw, has placed greater emphasis on security without adding to the difficulty of application. Because the left-hand screw rotates counter to the right-hand screw, any friction tending to loosen the latter automatically tightens the left-hand screw, so that the component parts of the apparatus cannot come apart.

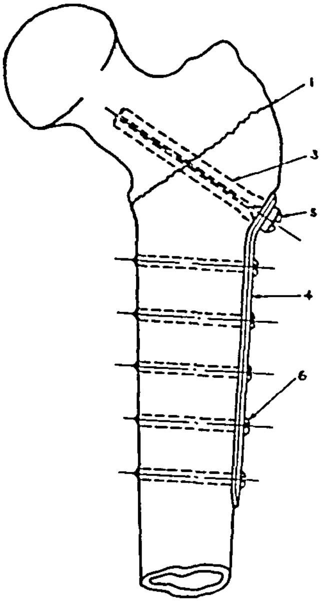

FIGURE 1

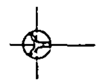

FIGURE 2

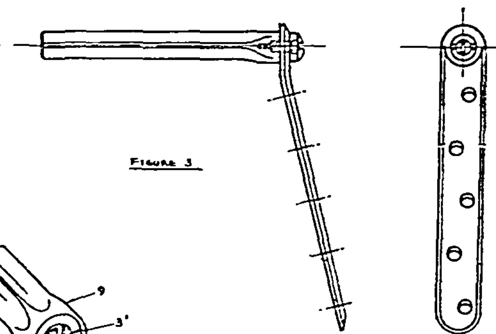

FIGURE 3

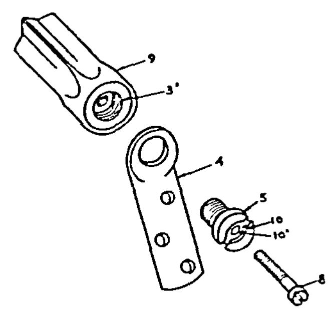

FIGURE 4

Figures 1, 2, and 3 show the nail and plate as used for the internal fixation of an intertrochanteric fracture; Figure 1, *3*, illustrates how the concentric screw passes through the No. ¼-20 screw to engage the nail threaded for this purpose. Figure 4 shows the details of application and construction of the apparatus. A cannulated Smith-Petersen nail is shown at *9*, the proximal cannulated portion of which, *3'*, has been threaded to a depth of one-quarter of an inch with a left-hand tap. The intertrochanteric plate is seen at *4*; *5* represents the ordinary No. ¼-20 screw through which a hole and seat, *10'* and *10*, have been bored for a left-hand No. 6-40 screw (*8*).

As the apparatus is put together, it is readily seen that after the screw (Fig. 4, *5*) has engaged the plate and nail, the concentric left-hand screw, *8*, is placed through screw *5* to engage the left-hand threads in the Smith-Petersen nail easily; it is tightened by twisting in a left-hand or counter-clockwise direction. By calculation, the combined tensile strength of the lock screw and main screw is sufficient to prevent breakage by bending, twisting, or shearing forces.

The authors feel the combination of nail and plate offers definite advantages in the internal fixation of certain intertrochanteric fractures, and in other procedures about the hip joint where the shaft of the femur is to be fixed to the trochanter, head, and neck. These advantages are: ease of application of the parts separately; interchangeability for variations in the length of nail and plate required; versatility, by the bend that can be placed in the intertrochanteric plate at its angle; and stability from rotation, because of the presence of the three flanges of the nail. These advantages have been somewhat offset heretofore by the lack of security afforded by the customary No. ¼-20 screw alone in holding the plate to the nail. It is felt that the lock screw described has increased the security without decreasing the ease of application; its use takes little more time than the ordinary procedure.

In addition, this nail plate can be secured with a serrated head on the nail and a well in the plate, which likewise has serration. The serrations help to lock the plate on the nail and prevent the turning of one on the other.

This device has been used by the authors, and has proved successful.

AN UNUSUAL ANOMALY OF THE INFERIOR PORTION OF THE SCAPULA

BY F. Y. KHOO, M.D., AND C. L. KUO, M.D., NANKING, CHINA

From the Department of Roentgenology, College of Medicine, National Central University, Nanking

The following case is recorded because of unusual features displayed by the right scapula.

F. H. W. (Hospital No. 6691), a Chinese male of forty-two years, was admitted to the Kung Li Hospital, Chengtu, Szechuan, in December 1944, because of nausea, vomiting, and hiccups, which had persisted for seven days. There was a history of a similar attack, several months before. He had had pain in the left side of the chest with fever about fifteen years before. He gave no history of trauma to the thorax, and inspection showed no obvious deformity or disability of the shoulders.

Roentgenographic examination of the gastro-intestinal tract showed signs suggestive of duodenal ulcer. During fluoroscopy of the chest, an unusual notching of the inferior portion of the right scapula was noted; the left scapula appeared normal. A roentgenogram of the right scapula (Fig. 1) showed that it was shorter than normal, owing to the absence of its inferior fourth. The most striking feature, however, was that the inferior aspect, instead of being pointed, ended in two processes, one on each side, with a deep semi-elliptical notch between them. The notch was about 2.5 centimeters wide and 1.5 centimeters deep, as measured from the roentgenogram. The medial process of this anomalous inferior portion of the scapula was somewhat blunt; it had a flat tip, measuring about 1.2 centimeters across. A tiny rounded projection of about 0.2 centimeter was seen, arising from the lateral part. The lateral process, which seemed to correspond to the so-called teres process designated by Hrdlička[2], was somewhat lower and narrower than the medial process, and had two larger projections or spines. One of the projections, which pointed lateralward, was about 0.5 centimeter long; the other, which was directed inferiorly, was 1 centimeter long. The rest of the scapula appeared normal. Its axillary border, however, was slightly wavy in outline and mildly concave. The vertebral border was fairly straight, except for a mild inclination lateralward above the spine of the scapula: this inclination represented the so-called fifth border of the scapula, as defined by Hrdlička[2]. Fluoroscopy also showed a minimal amount of chronic fibroproductive tuberculosis of the left upper lobe of the lung, associated with moderately extensive pleural thickening and adhesions about the left lower lobe.

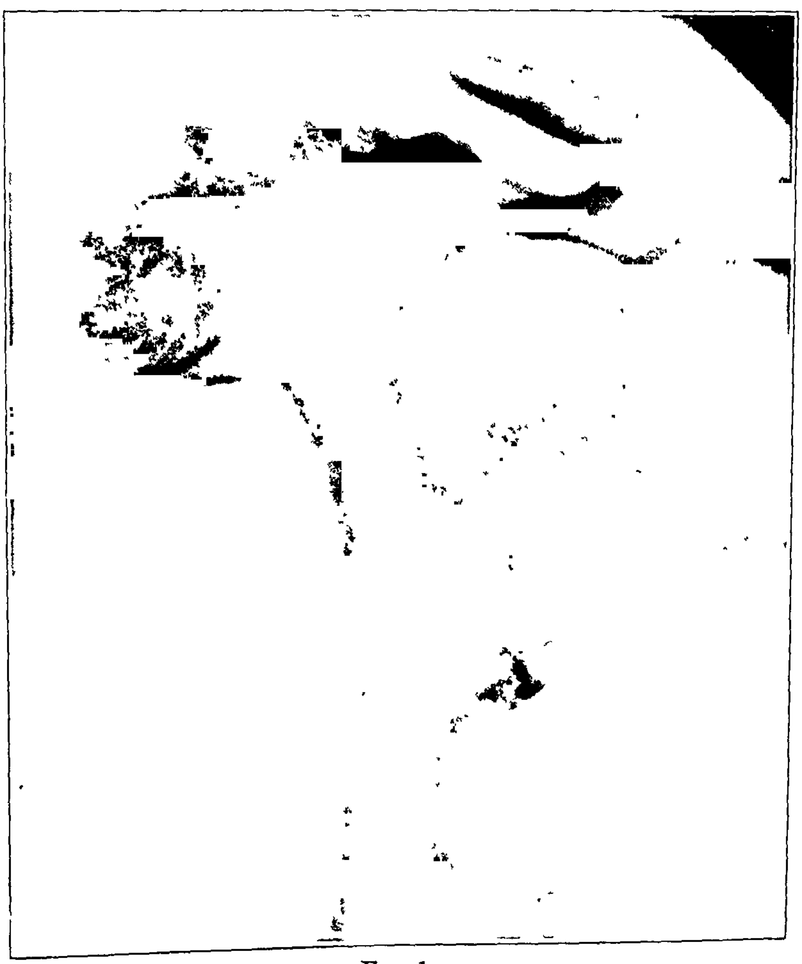

FIG. 1

Shows shortening of scapula with unusual bifid appearance of its inferior extremity.

DISCUSSION

Hrdlička and Gray have recently presented detailed studies of the human scapula, including a résumé of the previous literature. Hrdlička[2] wrote: "The scapula of man

is one of the most interesting bones of his skeleton. It presents numerous features and dimensions, . . . and many variations. Being essentially a functional product its anthropological value could hardly be expected to be very great, nevertheless its variants have more or less of phylogenic, ontogenic and racial significance."

According to Hrdlička [2]: "The body of the scapula presents three main shapes or types, namely, the triangular or wedge-shaped, with the vertebral border straight; the concave (or biconcave), with the vertebral border (or both vertebral and axillary) concave; and the convex, with its vertebral border markedly convex". The general shape of the malformed scapula in the case presented in this report would seem to conform to the second main type of Hrdlička, with mild concavity of the axillary border. Hrdlička also mentioned that ". . . the inferior angle may present a distinct border (fourth border) instead of a point; and the vertebral edge may definitely bend at the terminal point of the spine, which gives a fifth border above the spine". The scapula in our case also presented a mildly evident fifth border above the spine of the scapula.

Hrdlička illustrated five variants of the inferior angle (fourth border) of the scapula. A comparison shows that the scapula in our case corresponded somewhat in appearance to that of the fourth variant of Hrdlička, except that in the scapula of our patient the central notching was much deeper, and correspondingly larger and longer processes were present on each side; and, in addition, tiny projections were seen, arising from these processes. Since the changes in our case were much more pronounced than those which Hrdlička would consider as variants, we feel that the scapula described here could reasonably be considered as showing a developmental anomaly rather than just a developmental variation.

Many statistical figures of interest, too numerous to be discussed here, are supplied by Hrdlička. However, it will be pertinent to point out that, from an analysis of 1,285 scapulae of males of various nationalities, Hrdlička [2] found that a fourth border was present in 37.5 per cent. of all specimens, a fifth border in 10.4 per cent., and a combination of fourth and fifth borders in 24.0 per cent.; neither border was present in 28.1 per cent. of the specimens. He further stated that although, in general, "the two scapulae of the same subject closely resemble each other, yet there are numerous small and occasionally even marked differences in the shape as well as the size of the bones on the two sides". Hrdlička also found some sexual and racial differences: he discovered "that the juvenile scapula is far from finished in its form, but that it changes in many respects during the growth, and perhaps even during the earlier adult period". He believed that the additional borders of the scapula are of rather late development, and that "much of the ultimate form which the body of the bone achieves is of functional nature and due to muscular activity".

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DISLOCATION OF THE HEAD OF THE FIBULA

BY CAPTAIN ROBERT J. VITT

Medical Corps, Army of the United States

From the Orthopaedic Section, Station Hospital, Sendai, Japan

Dislocation of the head of the fibula is a rare injury, usually associated with a fracture at a lower level in the tibia. The dislocation may occur backward. forward, outward, or upward.

Anatomy of the Tibiofibular Joint

The articulation is an arthrodial joint, the opposing bones being covered with cartilage and joined by an articular capsule and anterior and posterior ligaments. The synovial membrane, lining the joint, occasionally communicates with the knee joint. The fibular collateral ligament joins the head of the fibula anterior to the apex. dividing the attachment of the biceps tendon into two parts.

Mechanism of Injury

The dislocation is usually due to direct trauma or, as mentioned previously, to the leverage produced by a fracture in the lower shaft of the tibia. In the four cases seen at this Hospital during the past year, all the dislocations resulted from parachute-landing falls in men whose ages ranged from eighteen to twenty. The history of the injury, as obtained from these paratroopers, was in each case one of a twisting, lateral fall at the time of striking the ground. Upon attempting to rise, they found that the knee felt "out of joint".

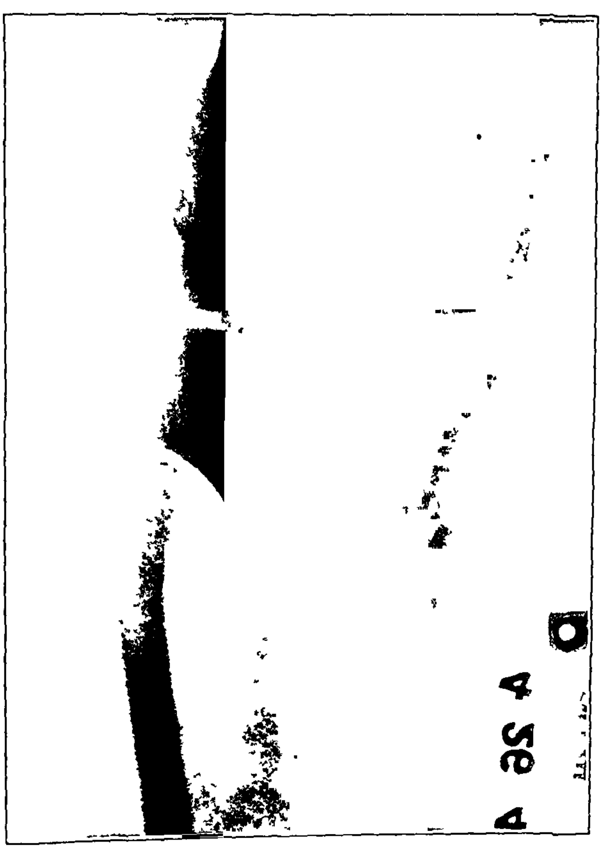

FIG. 1-A

FIG. 1-B

Fig. 1-A: Anteroposterior roentgenogram, showing abnormal prominence of the fibular head.
Fig. 1-B: In the lateral view, the head of the fibula is seen projecting anteriorly.

Examination

Inspection showed that the knob of the fibular head was protruding anteriorly, the deformity being further confirmed by palpation. There was no noticeable swelling, and only slight surrounding ecchymosis. The four cases seen were anterior dislocations, and were associated with inversion ankle sprains of varying degree. Extension of the leg was painful and limited to 160 to 170 degrees, with a similar 10 or 20 degrees of limitation of flexion. Both rotation of the leg on the femur and test of the fibular collateral ligament caused pain, but there was no evidence of tear of the cruciate ligament or collateral ligament. There was no evidence of hemorrhage into the knee joint. No sign of peroneal-nerve involvement was noted in any case.

Roentgenograms revealed forward and slight lateral displacement of the head of the fibula (Figs. 1-A and 1-B). Roentgenograms of the tibial and fibular shafts and the ankles were negative for fracture in all four cases.

TREATMENT

With intravenous sodium-pentothal anaesthesia, the dislocations were reduced by inverting the ankle, flexing the leg, and applying direct posterior pressure over the proximal portion of the fibular shaft and head. The reduction was accompanied by an audible snapping. The fibula gave no indication of redislocation upon manipulation, but an elastic bandage was applied with a felt pad over the peroneal nerve. Check roentgenograms revealed reduction of the dislocation with no evidence of fracture.

For the first week after reduction, the patients were allowed to be up on crutches without weight-bearing. Mild flexion and extension and muscle-setting exercises were encouraged. The second week, whirlpool and weight-resistance exercises were started, and weight-bearing was increased from partial to full.

The patients were discharged from the Hospital at the end of the third week. Follow-up visits revealed the patients to be asymptomatic, and in no case was there recurrence of the dislocation or sign of peroneal-nerve involvement. The men were discharged to full parachute duty, two months after injury.

COMMENT

In assuming the "parachute-landing position", paratroopers are taught to flex their legs and keep their feet together. In this manner, the fibular collateral ligament and the biceps femoris are in a relaxed state. As sharp inversion of the ankle causes tension of the peroneal muscles, and a lateral twisting motion of the trunk is transmitted to the tibia, the fibula is free to dislocate anteriorly. This, we may assume, is the mechanism of the dislocation.

It was not considered necessary to apply casts to these patients, inasmuch as the dislocation did not recur after reduction when considerable force was applied.

A MOBILIZER ATTACHMENT FOR THE STRYKER FRAME

BY CHARLES FERGUSON, M.D.

United States Public Health Service

From the United States Marine Hospital, Staten Island, New York

Patients with injuries of the spinal cord are occasionally treated on a urological service, because of their urinary difficulties. These paraplegics are cared for on the Stryker frame, as a rule.

It appeared that many of these patients could be further helped through exercise, and that, if they were able to move about through their own volition, their interest could be more fully maintained.

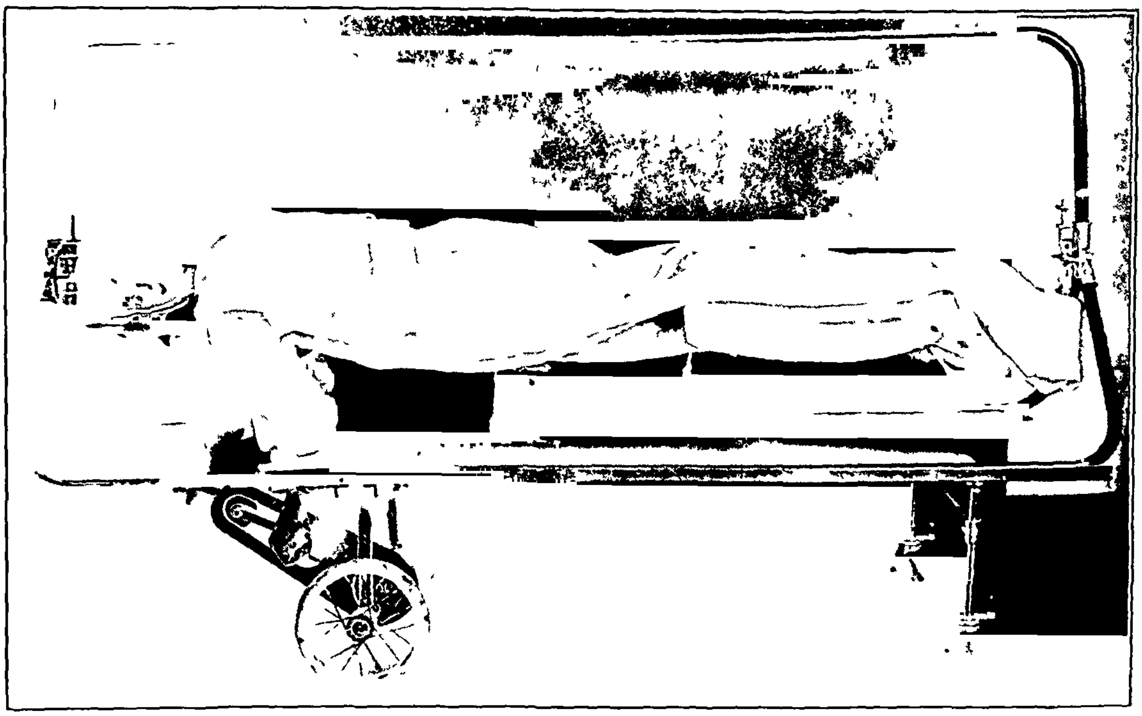

FIG. 1

It is possible to equip the Stryker frame with wheels, very easily and economically, for use as a propulsion device. A part of a child's tricycle was attached to the Stryker frame, to be used as front running gear (Fig. 1). The wheels on the rear of the frame are swiveled, enabling the patient to propel the frame with comparative ease. When the frame is held in a stationary position, set screws lock the wheels.

This arrangement does not interfere with care of the patient on the Stryker frame. Position of the patient is changed according to orders. The apparatus greatly helps in the development of the muscles in the non-paralyzed portions of the body.

NOTE: Acknowledgment is made to Michael Mordovanecy, machinist, whose skill was responsible for this adaptation of the Stryker frame.

MASSIVE HYPERPLASIA OF BONE FOLLOWING FRACTURES OF OSTEOGENESIS IMPERFECTA

Report of Two Cases

BY WALTER E. VANDEMARK, M.D., SIOUX FALLS, SOUTH DAKOTA
AND MANLEY A. PAGE, M.D., CHICAGO, ILLINOIS

From the Shriners' Hospital for Crippled Children, Chicago Unit

Two cases of osteogenesis imperfecta have been encountered at this Hospital in which an osseous mass developed rapidly at the fracture site, expanding in all directions; it was accompanied by local heat, redness, pain, and tenderness, and, in the case seen in the acute stage, by systemic fever. In both cases, the question of malignancy was raised by consulting orthopaedic surgeons; for this reason, the syndrome seems worth reporting. No record of this condition could be found in the literature at the time these patients were seen, although Dr. D. B. Phemister had seen a similar case some years before; the syndrome has recently been described by Baker [1].

CASE 1. H. F., a three-year-old white girl, was admitted to the Hospital on February 12, 1944, complaining of pain and tenderness in the middle third of the right femur. The child showed typical severe osteopsathyrosis, with blue sclera and curved, deformed extremities. Physical and roentgenographic examinations showed a transverse fracture of the middle third of the right femur with no appreciable displacement; this was splinted in plaster without preceding manipulation. The patient remained comfortable in bed until March 25, when, without any known trauma, clinical evidence appeared of a fracture in the middle third of the left humerus. After roentgenographic confirmation of a transverse fracture, with the fragments in good position, Buck's extension traction was applied in the longitudinal axis, one pound of traction being used. This held the fragments in good position. The child was quite comfortable with the arm in traction until two weeks after the fracture, when it was noted that the left arm was becoming larger, warm and red, and that it was definitely tender. There had been no known recent trauma, and there was no local ecchymosis. The child became more uncomfortable, and would cry when anyone touched the arm. For the first time, she had a low-grade fever with a temperature as high as 100 degrees. These symptoms continued and the hard, fusiform enlargement of the left arm expanded steadily, extending downward distal to the elbow.

The roentgenograms (Fig. 1-A) did not suggest malignancy, but, in view of the clinical course, a biopsy was performed on August 24, five months after the fracture had occurred. The mass appeared grossly as rarefied cancellous bone, with no suggestion of malignancy. The specimen was studied at the Laboratory of Orthopaedic Pathology, University of Chicago, and the lesion was reported to be benign. At this time the redness, heat, and tenderness began to regress. A month later, the arm seemed less hard and a bit smaller than it had been. Slow regression continued (Fig. 1-B) and the patient was discharged to the Out-Patient Clinic on November 2, 1944.

CASE 2. S. A., a six-year-old white girl, was seen in the Out-Patient Clinic, complaining of multiple deformities of the extremities. The history was that of severe osteogenesis imperfecta. The condition began with several birth fractures and included more than forty subsequent fractures. Examination showed blue sclera and rounded right-angled curves of both tibiae in an anteroposterior direction, which prevented walking. The right femur was very large and fusiform; the left was smaller. Three years and nine months before, there had been a spontaneous fracture of the right femur, in its middle third. The patient was seen by her local physician, who placed the limb in a plaster cast. According to the patient's mother, the physician then decided that the alignment was unsatisfactory; three weeks after the fracture had occurred, he manipulated the fragments into a more satisfactory position and immobilized the limb in a plaster cast. Within the next few days considerable pain developed, and the physician removed the cast. The thigh gradually became larger, the swelling was fusiform, hard, and tender, and the area was hot and red. No data are available regarding the systemic temperature.

A little over three weeks after this development, while the swelling was still increasing, the mother took the patient to an orthopaedic clinic of a university hospital, where she was seen by a leading orthopaedic surgeon. The mother said that she was told the lesion was probably malignant. Roentgenograms were later taken, however, and the diagnosis given was a benign condition of the fractured bone. The child subsequently remained at home in bed with the thigh splinted by pillows. The redness, heat, and tenderness cleared up "within a few weeks", according to the mother, and the fracture healed without further incident. The huge swelling did not regress, however, and the thigh has remained considerably enlarged.

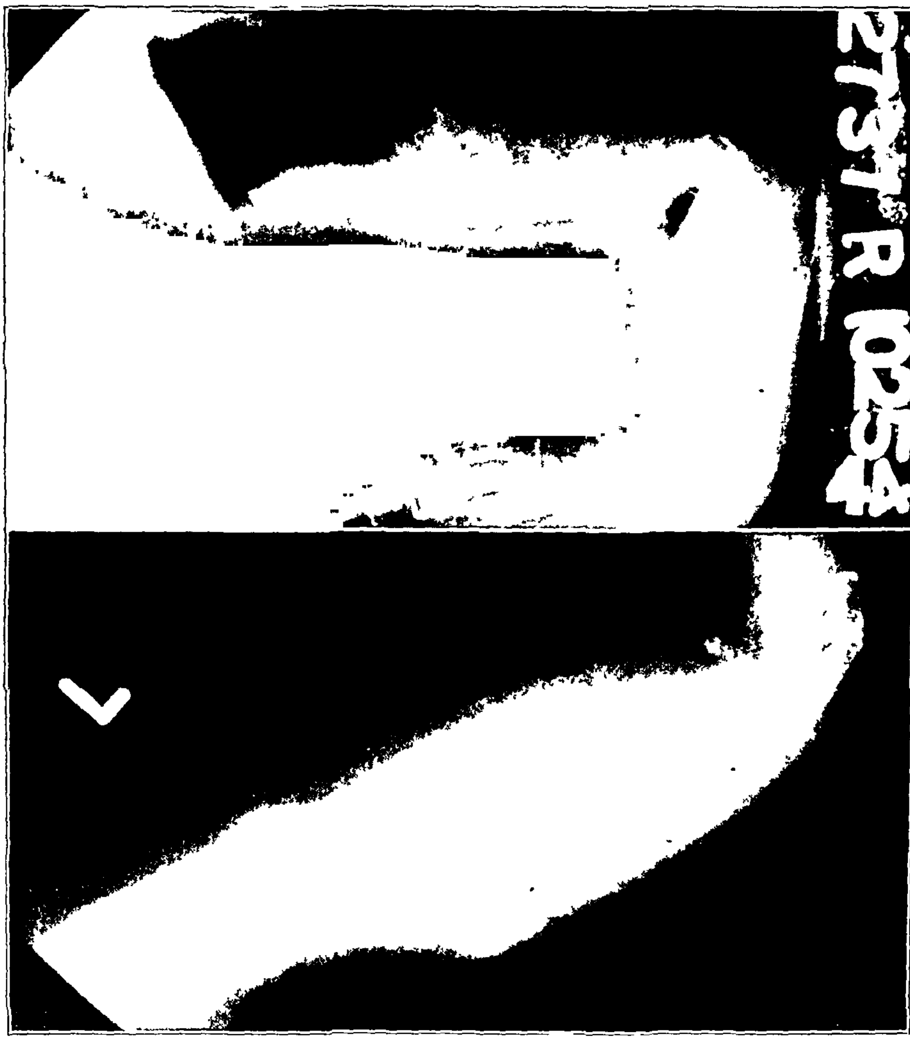

Fig. 1-B

Roentgenograms, taken seven months after fracture, show gradual regression of the process.

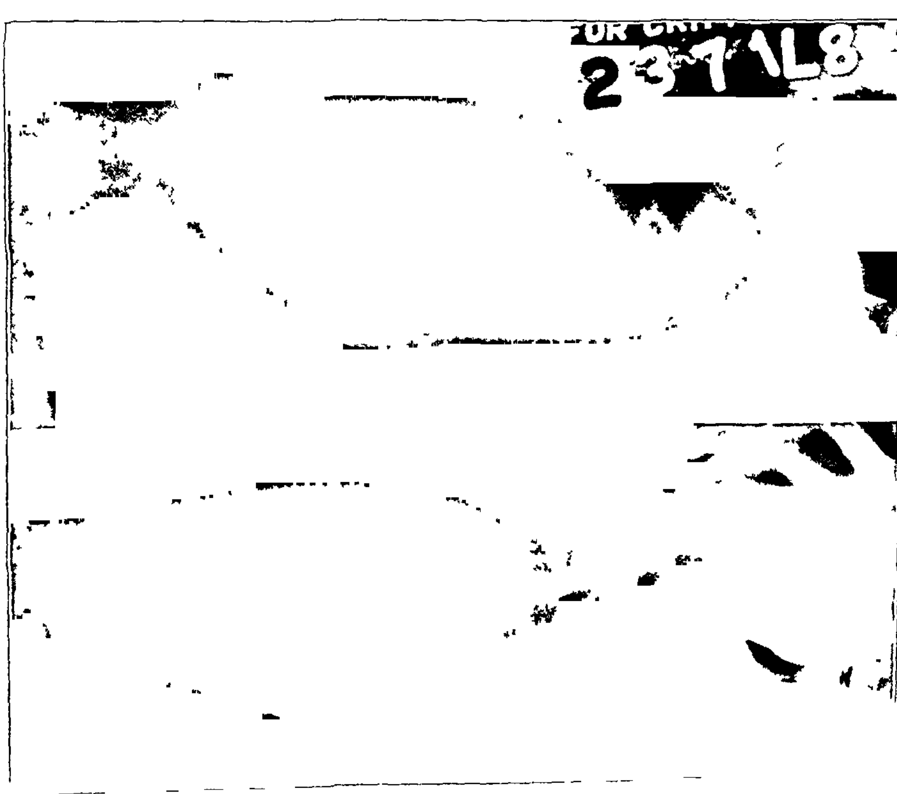

Fig. 1-A

Case 1. Roentgenograms show hyperplastic reaction, five months after fracture of humeral shaft.

Roentgenograms of the long bones were taken at the Shriners' Hospital, that of the right femur being shown in Figure 2. The child was placed on the Hospital's waiting list for corrective osteotomies of the tibiae.

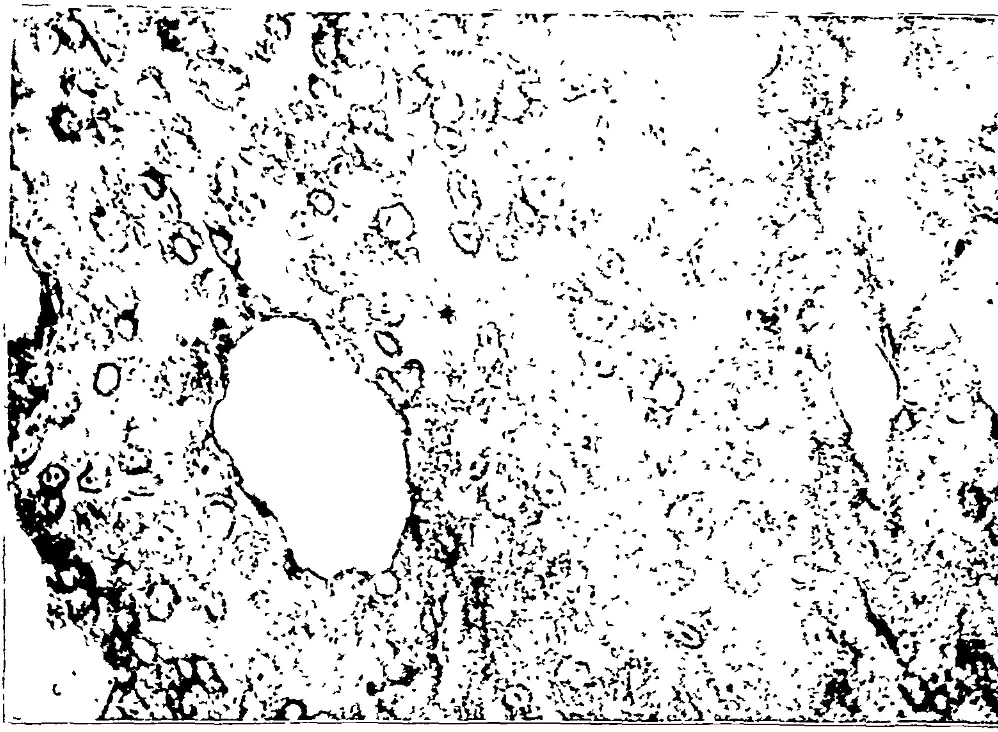

FIG. 1-C

Biopsy specimen (× 240). Poorly defined cells, somewhat resembling early cartilage cells, are diffusely distributed in a loose, basophilic granular stroma, with large vacuolar spaces, not resembling the tissue of callus or typical osteogenesis imperfecta.

FIG. 2

Case 2. Right femur, three years and nine months following the onset of massive hyperplasia.

The syndrome presented by these two children is of interest particularly in its differentiation from a malignant lesion, myositis ossificans, or ossifying hematoma, and from the rare cases of osteomyelitis at the site of a closed fracture. The clinical course and the microscopic histology (Fig. 1-C) differentiate it from these conditions. The exact nature of the process is obscure at present; it would appear to indicate a quantitatively exaggerated repair reaction of the osteoblasts, whose qualitative defect characterizes this bone dysplasia.

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ANTONIUS MATHIJSEN, THE DISCOVERER OF THE PLASTER BANDAGE

BY J. VAN ASSEN, M.D., ROTTERDAM, HOLLAND,
AND HENRY W. MEYERDING, M.D., ROCHESTER, MINNESOTA

As representatives of the International Society of Orthopaedic Surgery and Traumatology, the authors had the honor of laying a wreath and of assisting at the dedication of the monument to Dr. Antonius Mathijsen, on October 24, 1946, in Budel, Holland. The orthopaedic surgeons of the world and members of the medical profession of Holland, Dr. Mathijsen's native country, were proud to have one of their members receive this recognition for his invention of plaster bandages.

Antonius Mathijsen was born on September 4, 1805, at Budel, a small village in North Brabant, Holland, the son of Dr. Ludovicus Hermanus Mathijsen and Petronella Bogaers. He had seven brothers, of whom three likewise were physicians, and two sisters. His father thought that Antonius should become a military surgeon; the young man was first placed in the military hospital at Brussels, later in Maastricht, and finally at the large government hospital at Utrecht. He received his commission in the Army on July 14, 1828, and the degree of Doctor of Medicine from the University of Giessen in 1837.

In 1831, Dr. Mathijsen took part in the ten-day campaign in Belgium, at Ypres and Breda, and was honorably mentioned and decorated. In 1851, while stationed at the garrison in Haarlem, he worked at his plans for a plaster splint which would maintain immobilization of fractures of bone. Other methods had been tried by other men, but the results had not been good. Mathijsen experimented until he found a new and more efficient method of making a plaster splint.

Mathijsen wrote a monograph on a new method of application of the plaster in fractures, which was published in May 1852. In the introduction to this volume he stated that he had tried, above all, to find a good method of dressing the wounded on the battlefield. He pointed out that the majority of these patients, injured by firearms, had compound fractures that required special treatment; and it was his intention to find an immobilizing bandage which would permit safe transportation of the patient. As he conceived them, the requirements of the bandage were: (1) that it could be conveniently applied at once; (2) that it become hard in a few minutes; (3) that it be so applied that the surgeon would have access to the wound; (4) that it be adaptable to the circumference and shape of the extremity; (5) that it be of such consistency that it would not be damaged by suppuration or humidity; and (6) that it be not too heavy or too expensive.

Mathijsen's plaster bandage was constructed after the principles of Seutin's starch bandage. It proved to be economical and more practical than others used previously. He cut pieces of double-folded unbleached cotton or linen to fit the part to be immobilized; then the pieces were fixed and held in position by woolen thread or pins. The dry plaster, which was spread between the layers, remained two fingerbreadths within the edges of the cloth. The extremity was then placed on the bandage, which was moistened with water. Next, the edges of the bandage were pulled over, so that they overlapped one another, and they were held by pins. When an opening in the bandage was necessary, a piece of cotton wool, the size of the desired opening, was placed between the compresses, so that this area remained free of plaster. This type of dressing afforded rest to the injured parts by immobilization. In cases in which it was found necessary to enlarge the cast, enlargement could be achieved by the application of cotton bandages, four inches wide, rubbed with plaster and moistened.

Mathijsen's own description of the plaster bandage was the first accurate one. In 1854, in a French treatise, he gave a report of his results after the application of the plaster bandage, and he also mentioned various cases in which the patients had been treated by other surgeons. Moreover, he wrote to the Royal Academy of Belgium that the plaster bandage was his invention, and that it was not the result of collaboration on the part of several surgeons. In 1857, he described a practical pair of scissors for use in working with plaster.

By 1856, the value of the treatment by means of the plaster bandage had become appreciated. The method was commended in the periodicals of the Society of Surgery and Obstetrics, in Amsterdam, and of the Society of Physicians, in Vienna (by Dr. C. J. Cessner). In 1876, Mathijsen was requested by one of his friends, Dr. M. W. C. Gori, to present his invention of fixation by means of the plaster bandage at the Centennial Exhibition in Philadelphia, which he did.

Many honors were bestowed upon Dr. Mathijsen. He was made Knight of the Order of the Netherlands Lion and of the Oak Crown of Luxembourg, Major Surgeon of the Dutch Army, and member of the medical societies of Amsterdam, Hoorn, Utrecht, Brussels, Bonn, Halle, Vienna, Neuchâtel, and Zurich.

When we consider the significance of this work, we must also bear in mind the status of treatment of wounds and diseases of the extremities in the early 1800's. Prior to Mathijsen's invention, the treatment of a broken or wounded extremity was woefully inadequate, and such treatment often led to serious disability or to the loss of limb and life.

In 1870, at a time when Mathijsen's method of treatment of patients was not generally known, Zola in his famous book, *La Débâcle*, described the appalling inadequacy of the treatment of the wounded. The high mortality rate was markedly lessened by the discoveries of Pasteur, Lister, and Mathijsen.

Dr. Mathijsen died on June 14, 1878, at Hamont, Belgium, where he is buried.

1. Mathijsen, Dr. Antonius. Obituary. Nederlandsch. Milit. Geneesk. Arch., 2: 392–405, 1878.

JACOBUS VAN ASSEN

1881–1948

The death of Dr. van Assen on August 1 marks the passing of a distinguished surgeon and an exceptional gentleman whose place will not easily be filled. He will be sorely missed in his family circle, in the larger group of his professional colleagues, and especially in that wider circle of the handicapped and disabled of his country, to whom so much of his life was devoted.

Jacobus van Assen was born in Zwolle, Netherlands, on July 10, 1881. He studied medicine in Amsterdam and became a surgical assistant to Prof. Lanz. Later he became associated with Prof. Joachimsthal in Berlin.

In 1911 he began his work in Rotterdam. An institution, established in 1912 by Miss De Monchy, with the assistance of Dr. van Assen, led to the opening of the *Adriaanstichting* in Hillegersberg, near Rotterdam, in 1914. The *Adriaanstichting*, first projected as a home for physically handicapped and disabled children, became not only a home, but also a school, a hospital, and a training center for various occupations, the graduates of which might enter the world well equipped to earn their own living.

Dr. van Assen's thesis, presented in 1918, was entitled: "*Traumatische Aandoeningen van het Bewegingsapparaat*" (Traumatic Affections of the Locomotor Apparatus). Well in advance of the thinking of that day, he recognized the surgeon's responsibility not only for the general medical and surgical treatment indicated for the disabilities present, but also for the "medicosocial care" of the patient, to which attention was being directed for the first time,—a conception that covers an even more extensive field than is implied in the term "rehabilitation".

From this thesis two excerpts are significant: "It is often the task of the orthopaedic surgeon to treat the sequelae of injuries, which a long time after the actual injury still or again give cause for considerable or slight complaints. The books on orthopaedic surgery mostly remain silent on this subject, whereas the books on surgery, when discussing treatment of these injuries, do point out the importance of avoiding these consequences, but do not concern themselves with the treatment of these sequelae once they have arisen."

"As a physician, one should not consider one's task to be ended, when there is no further need of performing the surgical routine. One should look upon one's task as finished, only when the patient is at his work again."

In Holland, van Assen has done extremely important work both as a clinician and in his medical writing; more than one hundred publications on orthopaedic and medicosocial subjects has he contributed to the literature. Among other subjects, he wrote upon: "a vertebral deformity not yet described", a method for operating upon club feet, a method of treatment for spastic affections, and an osteotomy of the trochanter with pin fixation. Together with the teaching personnel of the *Adriaanstichting*, he worked out a method of teaching athetotic children with good intellectual capacity how to write.

Van Assen was a man of broad interests; he considered international exchange of ideas necessary. He was a Corresponding Member of the Belgian Orthopaedic Association, and an Honorary Member of the Dutch, French, and British Orthopaedic Associations.

He had been looking forward with keen anticipation to the Congress of the *Société Internationale de Chirurgie Orthopédique et de Traumatologie*, to be held in Amsterdam in September. He had been elected Vice-President of the Congress and had been active in preparations for it. In that memorable gathering, he was greatly missed.

News Notes

The Sixteenth Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, Illinois, January 22 to 27, 1949.

The Western Orthopaedic Association will hold its Annual Meeting on November 3, 4, and 5, at the St. Francis Hotel, San Francisco, California.

An **Egyptian Orthopaedic Association** has recently been formed. The President is Prof. M. Kamel Hussein, Professor of Orthopaedic Surgery at the University of Fouad, Cairo.

The American Society for Surgery of the Hand will hold its Annual Meeting in Chicago, January 21 and 22, 1949. The Secretary of the Society is Joseph H. Boyes, M.D., 1401 South Hope Street, Los Angeles 15, California; the Chairman of the Program Committee is Harvey S. Allen, M.D., 154 East Erie Street, Chicago, Illinois.

The Seventy-sixth Annual Meeting of the **American Public Health Association** will be held in Boston, November 8 to 12, 1948. Delegates are expected from all parts of the United States; from Canada, Cuba, and Mexico; from the Latin American countries; and from Europe and Asia. Executive Secretary of the Association is Dr. Reginald M. Atwater, 1790 Broadway, New York 19, N. Y.

From July 12 to 17, the **First International Poliomyelitis Conference** was held in New York City. under the auspices of The National Foundation for Infantile Paralysis, Inc. Delegates from thirty-eight nations attended. Papers were presented concerning the many phases of this disease; techniques of orthopaedic nursing were described; and new methods of rehabilitation were demonstrated. A resolution was passed by the Conference to establish a permanent congress on poliomyelitis.

The Annual Meeting of the **Sociedad Española de Cirugía Orthopédica y Traumatología,** the first since 1936, was held in Madrid on May 17 and 18, under the presidency of Dr. M. Salaverri of Bilbao.

Dr. J. Troncose of Vigo and Dr. San Ricart of Barcelona presented a paper on the treatment of scoliosis, emphasizing the importance of early diagnosis. They recommended operation, if conservative methods proved unsuccessful.

Several papers concerned medullary nailing according to the method of Küntscher. Dr. F. Jimeno Vidal of Barcelona discussed the complications produced by introduction of the nail,—alterations in bone physiology, infection, and disturbance of callus formation. His results with the method used in fractures of the upper extremity were unsatisfactory; he feels that the nailing is indicated only for transverse fractures of the middle third of the femur. Other authors, including Dr. F. Lopez de la Garma, of Madrid, Dr. Garcia Diaz of Oviedo, and Dr. Sierra Cano of Santander, presented more encouraging findings, especially in fractures of the shafts of the femur and tibia.

Dr. Sanz Ibañez of Madrid reported experimental findings in mice inoculated with the virus of poliomyelitis; Dr. Salaverri presented seven cases of arthrogryposis; and Dr. Sanchís Olmos of Madrid showed his results after osteotomy of the femoral neck in the treatment of dislocation of the hip joint in paralysis.

The 1949 meeting will be held in Jerez, Sevilla, and Cordoba.

The first **Inter-American Conference on Rehabilitation of the Crippled and Disabled** was held in Mexico City from July 18 to 24, 1948, by The International Society for the Welfare of Cripples, under the auspices of the Mexican Government Department of Public Health and Welfare. There were nineteen countries represented as follows: Argentina, Uruguay, Venezuela, Peru, Colombia, Bolivia, Guatemala, Nicaragua, Costa Rica, Ecuador, Honduras, Dominican Republic, Puerto Rico, Cuba, Canada, Spain, France, Mexico, and the United States. The total registration of the Conference was 188; seventy-eight representatives were from countries other than Mexico, and forty-five were from the United States. Many prominent orthopaedic surgeons were present from the Latin American countries.

Dr. Juan Farill, President of The International Society for the Welfare of Cripples, was the Chairman

of the Conference. The morning sessions, which were entirely on the social, economic, and medical problems of rehabilitation, were held in one of the conference rooms of the beautiful Palace of Fine Arts. The mid-day and afternoon sessions were clinical sessions, held at the Children's Hospital, the National Institute of Cardiology, the Central Military Hospital, and the Railroad Hospital. There were two afternoon sessions and two clinics presented by the orthopaedic surgeons of Mexico City and others. In addition, there were exhibits, and an afternoon session devoted to motion pictures showing different phases of rehabilitation. At the final session, Dr. Henry H. Kessler of Newark, New Jersey, succeeded Dr. Farill as President of the International Society.

The social features of the meeting started on the afternoon of July 17, with a party given by Dr. Farill for the delegates and their wives. A banquet was given on the first night by the Department of Health and Public Welfare, followed on the third day by a visit to the floating gardens at Xochimilco with a mid-day banquet given by the Mayor of the City of Mexico, Lic. Fernando Casas Aleman, in honor of the delegates. A reception on this same afternoon was given at the American Embassy by the Ambassador, Mr. Walter Thurston. On the final evening, a reception with a buffet supper was given by the Secretary of State, Mr. Torres Bodet, and the Department of State of Mexico, at the State Department Building. The kindness and hospitality of the Mexican Government and the doctors of Mexico City will long be remembered by all who attended. Time was allowed in the program for sight-seeing and visits to the points of interest in and about Mexico City.

One of the distinctive features of the meeting for those from the United States was the excellent translation from Spanish into English by the secretaries for the conferences and clinics. Dr. Farill is to be congratulated on the splendid organization and arrangements of the meeting.

LETTER TO THE EDITOR

In reference to the News Note concerning Dr. H. Earle Conwell's introduction of the term "Complex Simple Fracture" on page 792 of *The Journal* (Vol. 30-A, July 1948), I have the following approval and criticism:

The term "Complex" should most certainly be used to describe lesions of bone which involve branching fracture lines, joint surfaces, fragmentation, and such displacements as distort or disrupt adjacent non-osseous structures.

However, the word "Simple" should then be used to denote the opposite state,—i.e., the fracture which has a fracture line which is single, incomplete, or not displacing adjacent structures to a significant degree.

I wish to add further a suggestion to abandon the time-honored, obscure terms "Simple" and "Compound", which have referred to the state of the overlying skin, and in their places substitute "Closed" and "Open", terms we already know in the field of treatment of fractures.

Dr. Conwell's term would then become "Closed Complex Fracture", and fractures would be either "Closed" or "Open", "Simple" or "Complex".

John G. Hand, M.D., Philadelphia, Pennsylvania

The following letter is reprinted, by permission of the American Medical Association, from the Correspondence Department of the *Journal of the American Medical Association*, vol. 137, p. 211, 1948:

NOMENCLATURE OF FRACTURES

To the Editor: I have just received from Dr. H. Earle Conwell of Birmingham, Ala., a reprint of his note to THE JOURNAL with regard to nomenclature of fractures. Dr. Conwell recommends the term "complex simple fracture" for "complicated simple fracture" and quotes Webster's definition of complex. However, he quotes only the definition of the noun, which does not apply. To make sense he should have quoted the definition of the adjective, viz., "involving many parts; complicated; intricate". Not to complex (Webster's transitive verb) the issue, the real confusion stems from the original terms, simple and compound, neither of which means anything as applied to fractures.

As one not learned in etymology or other branches of philology, including semasiology, but acknowledging the need of descriptive values in nomenclature, I suggest dropping the designations "simple" and "compound" in favor of "closed" and "open". Qualifying adjectives such as complicated, crushing or comminuted should be used together with morphologic descriptive terms as to location of the fracture in the bone and its direction.

Certainly a fracture of the tibia and fibula with the skin unbroken but everything else in the leg completely smashed can hardly be called a simple fracture, no matter what descriptive adjectives may be applied fore or aft.

Richard B. Dillehunt, M.D., Portland, Oregon

Book Reviews

DIAGNOSTIC ET TRAITEMENT DES MALADIES DE LA COLONNE VERTÉBRALE (Diagnosis and Treatment o Diseases of the Spine). Jean Saidman. Paris, G. Doin et C^ie^, 1948. 4,500 *francs.*

This is a monumental work of 1230 pages with 1324 illustrations, diagrams, line drawings, and roentgenograms, published in two volumes. It is a difficult task to give full justice to this magnificent treatise in ar ordinary book review.

According to the author, this work was conceived as a synthesis of the enormous amount of materia scattered throughout the special literature on diagnosis and treatment of diseases of the spine. The authoı prepared 150 pages of references which, unfortunately, could not be published on account of paper shortage Many thousands of roentgenograms had to be examined before the typical and atypical illustrations for thι book could be selected. These illustrations and their detailed analysis in the text represent a most comprehensive atlas of roentgenography of the spine.

The general plan includes several considerations:

1. Rules on clinical examination, technique, interpretation of painful phenomena, investigation oi articular function, muscle reactions, and medullary radicular and vasomotor complications. The roentgenographic examination includes a detailed description of normal roentgenographic findings.
2. General processes affecting the vertebral body, discs, and articulations.
3. Deformities of the vertebral column, which are static syndromes produced by various causes.
4. Changes connected with slow modifications of the bony, disc, or articular structures, differently manifested in infancy, adolescence, adult life, and old age.
5. Destructive lesions, including traumatic, infectious, and neoplastic changes.
6. Congenital changes.
7. Clarification of terminology. Etiological, statistical, and theoretical considerations were eliminated unless they had some relation to diagnosis or treatment.

The introduction deals with the functional, anatomical, and etiological factors of diagnosis. The text is divided into twelve chapters under the following titles: General Processes Affecting the Spine; Radiodiagnosis of the Spine; Static Deviations of the Spine; Affections of the Intervertebral Discs; Trauma of the Spine; Tuberculosis of the Spine; Non-Tuberculous Infectious Spondylitis; Osteocartilaginous Dystrophies of Growth; Osseous Dystrophies of the Adult; Vertebral Arthritides; Tumors of the Spine; and Congenital Malformations.

The author is primarily a roentgenologist. This is reflected in the description of the various afflictions of the spine, with a definite preponderance of the diagnostic portion over the portion dedicated to treatment. The author discusses various types of physical therapy. Descriptions of surgical treatment are usually of a general character, and contrast with the detailed and excellent descriptions of diagnosis and evolution of the various diseases of the spine. A few of the most recent methods of orthopaedic surgery, as used in the United States, are mentioned.

The abundance of information and the general excellence of the text and illustrations justify high recommendation of this book to the specialists in orthopaedic surgery and in roentgenology who are familiar with the French language. It may even be of importance to the reader who possesses only a superficial acquaintance with French.

IDENTIFICATION OF TUMORS. ESSENTIAL GROSS AND MICROSCOPIC PATHOLOGIC FEATURES SYSTEMICALLY ARRANGED FOR EASIER IDENTIFICATION. N. Chandler Foot, M.D. Philadelphia, J. B. Lippincott Company. 1948. $6.00.

According to the author's preface, this book was compiled "to serve as a brief guide to the identity of tumors and to stimulate further study of them".

Consisting of 394 pages, the book is so designed that chapters and subheadings are strikingly apparent to the reader's eye. A systematic pattern of presentation, boldly outlining the name and synonyms of each tumor, as well as its source, site of growth, gross and microscopic appearances, sites of metastasis, and prognosis, is used effectively. In instances where such considerations are significant, the age and sex relationships are briefly stated.

The first nine chapters, comprising Part I, are devoted to neoplasms of general distribution, including tumors of connective tissue, cartilage, bone, muscle, fat, serous membranes, lymphoid tissue, and epithelium. The larger segment of the book (Part II) describes the neoplasms that are identified with the organ systems of the body, and include the regions of the ear and eye and the skin. The final chapter contains: (1) a short discussion of fixation of tissues and staining procedures and (2) a tabular locator for tentative identification

of neoplasms. In this table of 26 pages, the author comments on morphology: type cell, stroma or matrix, differentiation, mitotic figures, other features, chemical admixture, and diagnosis.

The book contains 241 text figures. These photomicrographs have captured, for the most part, the essential histological pattern of the majority of tumors described. Since the gross and roentgenographic appearances of the neoplasms are not illustrated, the reader must depend upon the brief descriptive comment in the text for information concerning these important features.

No statistical tables are included. Except for an infrequent notation in the text, in a caption, or in a footnote, the reader receives no guidance to more comprehensive reports on a particular tumor he may be interested in studying.

The contribution to the current literature that is afforded by this book resides in the fact that it systematically presents a brief and readily identified account of the majority of neoplasms that will be encountered by the clinician and pathologist. Having identified a particular tumor, the physician ordinarily will need to consult more detailed reports to satisfy his interest in the lesion and to become fully acquainted with its significance.

Students of medicine and physicians will find the book useful for orientation, review, and quick reference. Physicians in training in pathology will find acceptable aid in the identification of neoplasms by histological methods. Thus, it would seem that the author had fulfilled the stated objective of providing "a brief guide to the identity of tumors". The corollary objective ("to stimulate further study of them") will be fulfilled in accordance with the interest of the reader and the purpose for which the book is consulted.

Regional Orthopaedic Surgery and Fundamental Orthopaedic Problems. Number II. The American Academy of Orthopaedic Surgeons. James E. M. Thomson, M.D., Editor. Ann Arbor, Michigan, J. W. Edwards, 1948. $7.50.

The Instructional Courses, given each year preceding the scientific program of The American Academy of Orthopaedic Surgeons, have proved to be a very popular feature of the meetings. The plan of recording these courses not only provides a permanent record for those who attend the courses, but presents in textbook form a concise summary of the material presented by members of the faculty, making it available to many who cannot be present at the Academy meetings. The volume just published is the fourth in the series, and covers the Instructional Courses presented at the meeting in January 1947.

Of special interest in this volume are the addresses on the history of orthopaedic surgery of the nineteenth century in New York City, in Philadelphia, and in the western part of the United States. These were presented at the historical dinner, held in connection with the Instructional Courses. The section closes with an appreciation of Dr. John Ridlon, who played so important a part in the early years of American orthopaedic surgery.

Numerous changes in the format make this issue more attractive than the previous volumes.

Rheumatism and Soft Tissue Injuries. James Cyriax, M.D., B.Ch. (Cantab.). London, Hamish Hamilton, Ltd., 42 shillings; New York, Paul B. Hoeber, Inc., 1948. $9.50.

Anyone who sees patients with "rheumatic diseases" and soft-tissue injuries will certainly agree with Dr. Cyriax that there is great need for more general knowledge of the accurate diagnosis of these conditions. This book presents in systematic fashion the means by which exact localization of involved structures can be determined. In respect to its handling of this portion of its subject, the book can be highly approved. The various anatomical areas, the lesions of which lend themselves to unified discussion, are taken up in separate chapters. The diagnostic and therapeutic methods recommended are well illustrated by diagrams and plates. Other chapters are devoted to more general topics, such as referred pain, traumatic and rheumatic inflammation, neuritis and perineuritis, treatment by movement, anaesthesia and analgesia, functional pain, and the problem of rheumatism and non-specific arthritis. There is an excellent chapter on the relationship between the doctor and the physical therapist.

In the portions of the book devoted to soft-tissue injuries, there is a very healthy insistence upon accuracy in diagnosis and in terminology. The use of such vague terms as "rheumatism", "fibrositis", and "fasciitis" without designation of the tissue affected is rightly decried. The logical distinction between "neuritis" and "perineuritis" is properly stressed. Both in the chapter on referred pain and throughout the book, the important fact that pains radiate segmentally is utilized. In spite of the undoubted demonstration of this by Lewis and Kellgren over ten years ago, the belief is still too widespread that peripheral projection of pain is evidence of nerve involvement.

The author adopts a conservative attitude toward the treatment of intervertebral-disc protrusion, and rightly advises against operation unless the stage of sciatica from root pressure has been reached. He does not use myelography in the diagnosis of disc lesions, and states rather sweepingly that for this purpose myelography has been abandoned.

The use of deep massage for lesions of muscles, tendons, ligaments, and fascia, for contractures of joint capsules, and for the late stages of subdeltoid bursitis, is strongly recommended. The manipulative treat-

ments of tennis elbow, adhesions about various joints, sacro-iliac subluxation, and protrusions of inte vertebral discs are described. The text lays insufficient emphasis on the fact that these manoeuvres are to l attempted only by those specially qualified by training and experience. Manual treatment of intestinal spası is described. The author attributes success to this measure in patients who were unable to obtain relief froı other types of treatment.

No field in medicine or surgery is more open to controversy than the problem of rheumatism. It is, ther fore, not surprising to find statements on this subject with which one does not agree. Rheumatoid arthrit is grouped, along with infective arthritis and spondylitis deformans, as one of the infective arthritides. Th concept is not only awkward, but has the disadvantage of prejudicing one to a belief in the infectious etiolog of this disease, when in truth no sound evidence for such a conclusion has ever been brought forth. The authc states that he is tempted to regard rheumatoid arthritis as a disease caused by a fibrotrophic virus. It is th opinion of the reviewer that the author does not stress sufficiently the importance of physical therapy in th treatment of rheumatoid arthritis; and that a great deal too much emphasis is placed upon the value of gol therapy in this disease.

Medullary Nailing of Küntscher. First English Edition. Lorenz Böhler, M.D. Translated from th Eleventh German Edition by Hans Tretter, M.D. Baltimore, The Williams and Wilkins Company 1948. $7.00.

Dr. Böhler, whose books on the treatment of fractures have been translated into several languages an recognized as of great value by surgeons of many lands, is an enthusiastic advocate of the method of medul lary nailing described by Küntscher in 1940. As Director of the *Unfallkrankenhaus* in Vienna, where thou sands of fractures are treated each year, he has had unusual opportunity to give adequate trial to thes newer methods. His broad experience has led to mature deductions as to the indications and contra-indica tions of the various techniques.

Dr. Böhler believes that: "Küntscher's medullary nailing is an astonishing and important innovation ir traumatic surgery. With careful selection of cases and proper technique it is superior to all previous methods for the treatment of fresh closed fractures, especially those of the femur." He feels that this form of nailing should not be used in fractures of the radius and ulna, in fresh closed and compound fractures of the tibia, and only in exceptional cases of closed fractures of the humerus. His conclusions as to the value of the method are based upon some 600 cases seen or treated by him.

In a perusal of the literature and in verbal reports, however, he found that the use of the Küntschei method in some hospitals had been less successful; that, in addition to the good results, a large number oi complications and failures had been reported. Believing that these unfortunate results had come because many surgeons, in their first enthusiasm for the Küntscher method, had overlooked the fact that it could not be used without due regard for the general condition of the patient or the fundamental principles of fracture treatment, Dr. Böhler, in this book, has tried to point out the circumstances leading to serious complications from the use of the method. He feels that many of the failures have been due to faulty technique and to lack of understanding of the contra-indications. This enthusiastic support of the method in carefully selected cases, tempered with his extreme caution, both in the selection of cases and in his technique, explains the form of presentation and the purpose of the book.

The first portion of the book, the "General Part", discusses the "Operative Treatment of Fresh Closed Fractures with the Medullary Nail of Küntscher without Exposure of the Fracture Field", the "Operative Treatment of Fractures with the Medullary Nail of Küntscher through Exposure of the Fracture Field", and the "Complications of Medullary Nailing".

The second half of the book, the "Special Part", discusses fractures of the different long bones, explaining concisely, yet in some detail, the methods of choice, as well as the contra-indications for each alternative method, in the specific types of fractures. He recognizes that increased knowledge of the role of antibiotics may later make safe the use of the Küntscher nailing in types of fractures where it is now condemned.

The book is an excellent translation of the last German edition, previously reviewed in *The Journal* (July 1947). Those who have followed Professor Böhler's teachings will welcome this English version, in which he has so carefully evaluated the Küntscher method of treating fractures of the long bones.

Nursing for the Poliomyelitis Patient. Joint Orthopaedic Nursing Advisory Service. New York, 1948.

The Joint Orthopaedic Nursing Advisory Service of the National Organization for Public Health Nursing and the National League of Nursing Education has prepared a small handbook for nurses engaged in the care of patients with poliomyelitis.

The nature of the disease is discussed briefly. Then the phases of nursing care are outlined, special attention being given to procedures useful in the acute and early convalescent stages of the disease. Line drawings illustrate the optimum positions for the patient, and the method of application of packs. One section is devoted to nursing the patient in a respirator.

This booklet is written clearly and concisely, and contains practical information on both the physical and psychological rehabilitation of these patients.

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ACKNOWLEDGMENTS

The Journal wishes to acknowledge receipt of the following publications, which have been sent to Editorial Department:

Analecta Medica (México), **8:** Núms. 2, 3, y 4, 1947.
Anales (Valencia, Spain), **2:** Núms. 2, 3, y 4, 1947.
Boletín del Colegio Médico de la Habana (Cuba), **10:** Núms. 5–12, 1947; **11:** Núms. 2, 3, y 4, 1948
Boletín del Instituto de Patología Médica (Madrid), **2:** Núms. 11 y 12, 1947; **3:** Núms. 1–7, 1948.
Boletines de la Sociedad de Cirugía de Rosario (Argentina), **14:** Nos. 4–8, 1947; **15:** No. 1, 1948.
Brasil Médico-Cirúrgico (Rio de Janeiro), **9:** Nos. 1–6, 1947; **10:** Nos. 1, 2, e 3, 1948.
The Bulletin of the U. S. Army Medical Department (Washington, D. C.), **7:** Nos. 10 to 12, 1947; Nos. 1 to 9, 1948.
Cleveland Clinic Quarterly (Cleveland, Ohio), **14:** No. 4, 1947; **15:** Nos. 1 to 3, 1948.
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Médica (Matanzas, Cuba), **6:** Núms. 5 y 6, 1947; **7:** Núms. 1, 2, y 3, 1948.
Medical Radiography and Photography, **23:** No. 2, 1947; **24:** Nos. 1 and 2, 1948.
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The Physiotherapy Review (New York, N. Y.), **27:** Nos. 5 and 6, 1947; **28:** Nos. 1 to 4, 1948.
The Record (Washington, D. C.), **4:** No. 5, 1948.
The Red Cross Courier (Washington, D. C.), **27:** No. 9, 1948.
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University of Chicago (Chicago, Illinois), Announcements: The School of Medicine, 1947–1948.
Verbandlehre für Schwestern, Helfer, Studenten und Ärzte. I. Teil. Binden-, Tuch-, Klebe-, Druck- u blutsparende Verbände. Prof. Dr. Lorenz Bohler. Wien, Wilhelm Maudrich, 1947.